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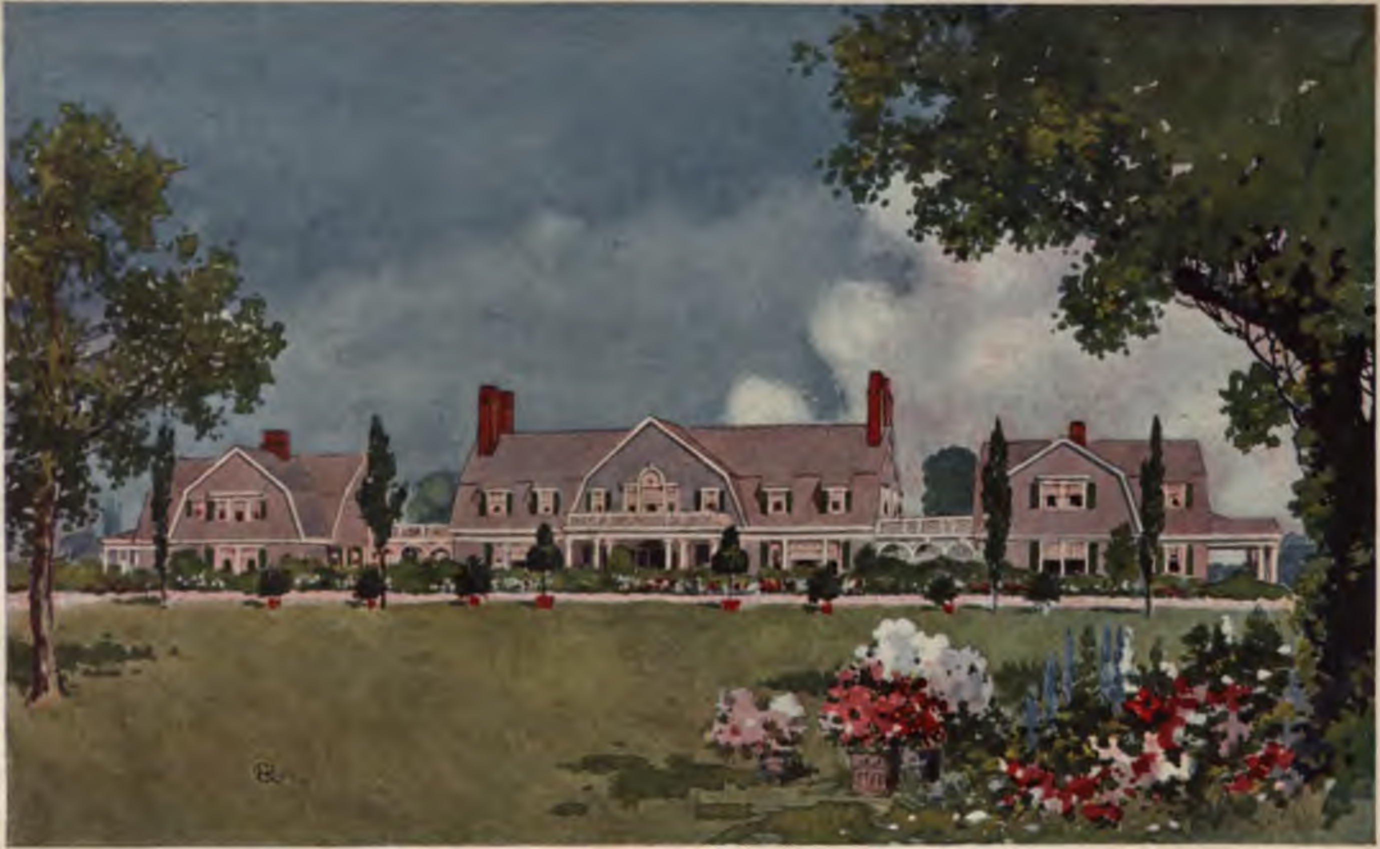

"DREAMWOLD," THE FARM OF THOMAS W. LAWSON, ESQ., SCITUATE, MASS.

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Cyclopedia
of
Architecture, Carpentry, and Building

A General Reference Work
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Grateful acknowledgment is here made also for the invaluable co-operation of the foremost architects, engineers, and builders in making these volumes thoroughly representative of the very best and latest practice in the design and construction of buildings; also for the valuable drawings and data, suggestions, criticisms, and other courtesies.

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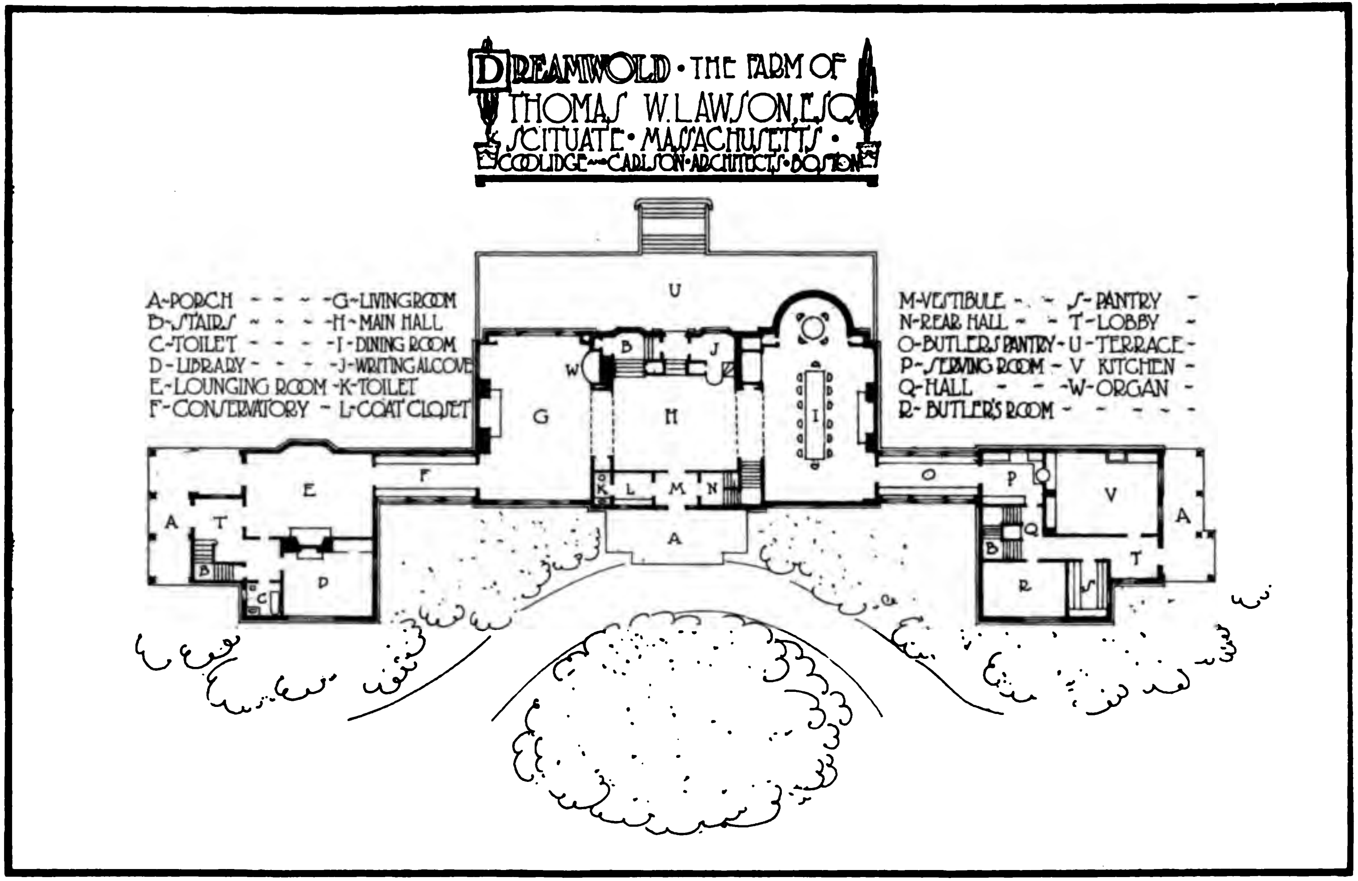
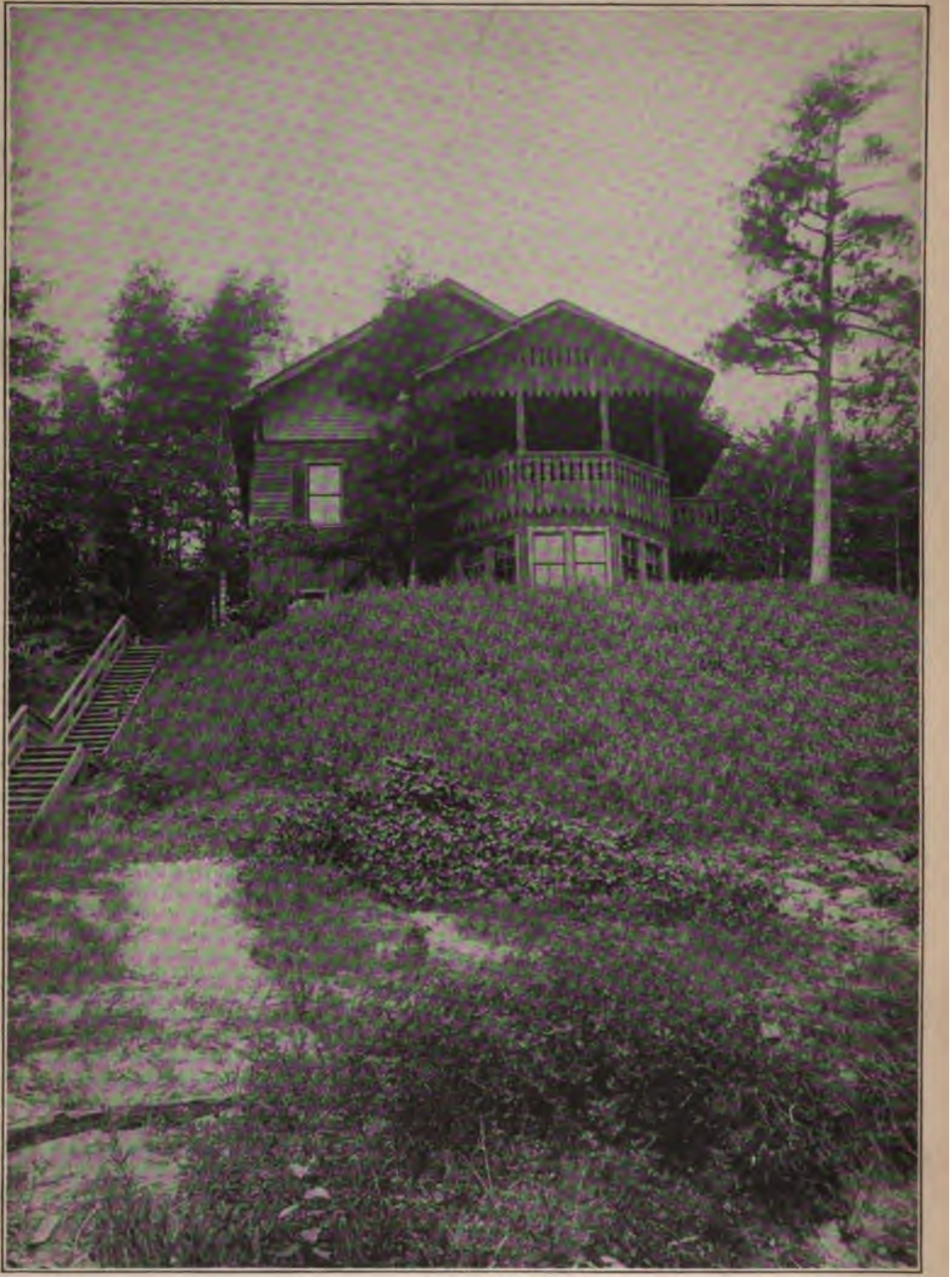


PLAN OF "DREAMWOLD," THE FARM OF THOMAS W. LAWSON, ESQ., SCITUATE, MASS.
Coolidge & Carlson, Architects, Boston, Mass.
For Exterior View, Reproduced in Color, See Frontispiece in this Volume.



SUMMER COTTAGE FOR THE MISSES DUMMER, AT HARBOR POINT, MICH.

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Built in 1903. Cost, $7,300. Plans and Interior are Shown on Pages 86 and 90.

Foreword

THE rapid evolution of constructive methods in recent years, as illustrated in the use of steel and concrete, and the increased size and complexity of buildings, has created the necessity for an authority which shall embody accumulated experience and approved practice along a variety of correlated lines. The Cyclopedia of Architecture, Carpentry, and Building is designed to fill this acknowledged need.

¶ There is no industry that compares with Building in the close interdependence of its subsidiary trades. The Architect, for example, who knows nothing of Steel or Concrete construction is today as much out of place on important work as the Contractor who cannot make intelligent estimates, or who understands nothing of his legal rights and responsibilities. A carpenter must now know something of Masonry, Electric Wiring, and, in fact, all other trades employed in the erection of a building; and the same is true of all the craftsmen whose handiwork will enter into the completed structure.

¶ Neither pains nor expense have been spared to make the present work the most comprehensive and authoritative on the subject of Building and its allied industries. The aim has been, not merely to create a work which will appeal to the trained expert, but one that will commend itself also to the beginner and the self-taught, practical man by giving him a working knowledge of the principles and methods, not only of his own particular trade, but of all other branches of the Building Industry as well. The various sections have been prepared especially for home study, each written by an acknowledged authority on the subject. The arrangement of matter is such as to carry the student forward by easy stages. Series of review questions are inserted in each volume, enabling the reader to test his knowledge and make it a permanent possession. The illustrations have been selected with unusual care to elucidate the text.

¶ The work will be found to cover many important topics on which little information has heretofore been available. This is especially apparent in such sections as those on Steel, Concrete, and Reinforced Concrete Construction; Building Superintendence; Estimating; Contracts and Specifications, including the principles and methods of awarding and executing Government contracts; and Building Law.

¶ The Cyclopedia is a compilation of many of the most valuable Instruction Papers of the American School of Correspondence, and the method adopted in its preparation is that which this School has developed and employed so successfully for many years. This method is not an experiment, but has stood the severest of all tests—that of practical use—which has demonstrated it to be the best yet devised for the education of the busy working man.

¶ In conclusion, grateful acknowledgment is due the staff of authors and collaborators, without whose hearty co-operation this work would have been impossible.

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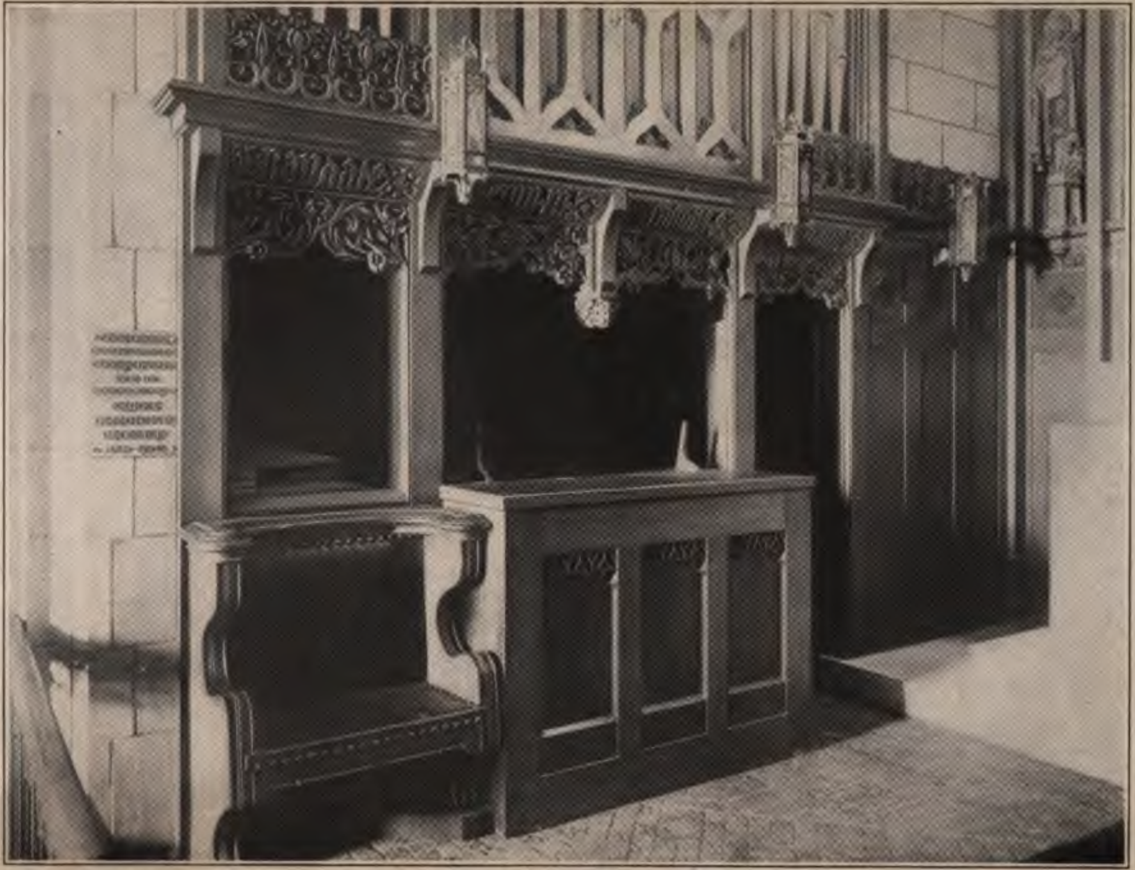

GRACE MEMORIAL CHAPEL, CHICAGO, ILL.

Cram, Goodhue & Ferguson, Architects, Boston and New York.
Carved Quarter-Sawed Oak of Lower Portion of Organ Case. Oak is Stained and Waxed. For Exterior and Interior, See Vol. I, Page 10, and Vol. II, Page 74.

CARPENTRY

PART I

INTRODUCTION

[Townsend, Gilbert]

The carpenter has always been a worker in wood and probably will always be so, unless we are so foolish as to neglect the newer art of Forestry to such an extent that in the course of time we have no wood wherein to work and with which to build and decorate our habitations. The building and the decoration of houses and other structures has always been the special contribution of the carpenter to the general welfare of the community, and this feature has distinguished him from other woodworkers such as carriage builders, shipbuilders, coopers, and makers of various implements. But whereas the carpenter formerly did all the work connected with the building or decoration of the structure, he now performs only a small part of it. At one time he was called upon to prepare the rough lumber for framing, erect the building, make the doors and windows together with their frames, and then make and put in place all the outside and inside finish, even including the furniture. In these days, however, factories are doing a great deal of this work, such as the manufacture of doors and window sash, interior finish, furniture, etc., and the lumber which was formerly prepared by hand is now sawed, cut, planed, molded, and even sandpapered by machinery, leaving for the carpenter the preparation of the framing of such buildings as are not large enough to be built of brick, stone, or steel, and the putting in place at the building of the exterior and interior finish which has previously been made ready so far as possible at the factory. The old-time joiner has given way to the modern cabinet maker or the factory woodworker, and his plane, saw, and chisel have been replaced by electrically-driven machinery of the planing mill and the door factory. Nevertheless, the principles upon which the art of carpentry is based have not changed, and we still use the

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formulas, and profit by the wisdom which has come down to us from our fathers.

The carpenter has always found at hand his material provided by Nature, needing only to be cut down and shaped to suit his purposes. It is easily worked, beautiful in texture, and capable of being treated with paints, oils, and varnishes in such a way as to preserve it and at the same time give it a pleasing appearance. So suitable is wood for purposes of interior decoration that now when other materials such as sheet metal are substituted for it on account of their greater durability or their superiority as fire resistants, great pains are often taken to make these materials look like wood by the skillful use of paints and varnishes, and such good results have been obtained along this line, and the grain of the various kinds of wood has been so closely imitated, that one not accustomed to woodwork in a business way can hardly distinguish the real wood from the imitation.

A knowledge of the characteristics of this material which plays so important a part in our lives and which is so plentiful, especially in the more recently settled parts of the earth, is sure to prove of advantage to all, and such knowledge is an absolute necessity to the carpenter, architect, or other user of wood.

Unlike many of the other materials used in building, wood has life and has come into existence by a process known as growth, and these two facts have a very important bearing on the use of wood in construction, as they affect both its physical characteristics and its action after it has been put in place in a building. In order, therefore, to be able to make use of wood intelligently, it is necessary to know something about its mode of life, its method of growth, and the way in which it will act after it has been cut away from the tree, killed, so far as it is possible to kill it, by seasoning or drying, and then setting up in place. All woods are not the same in these respects; in fact, no two kinds of wood are exactly the same in structure, nor will they behave in the same way even under the same conditions, and this makes it necessary to select them very carefully for various purposes and for use in various places.

While it is true that no two kinds of wood are exactly the same in structure, they still have some things in common. For example, all wood is a vegetable product, and all wood is built up in the same general way out of a very great number of individual parts called cells, or fibers, which are like so many tiny pockets filled with a fluid substance. The size, shape, and arrangement of these little cells is different in different kinds of wood, and this accounts for the differences in appearance, texture, and durability. Wood is largely composed of carbon, which accounts for the readiness with which it takes fire and the heat which it gives off when burned. There is also a considerable quantity of water, the exact amount depending upon whether the wood is seasoned or is still green, and even seasoned wood, if it is left lying about in a damp place, will absorb more or less moisture from the atmosphere.

There are two words which are used to describe the wood used for building purposes, namely, *timber* and *lumber*. Timber is the name which can properly be applied to any wood which is suitable for structural uses, when the material is in its natural state, before it has been cut down and prepared for the market. Lumber is the word which should be used to describe the timber after it has been cut down and sawed up into pieces ready for use. In practice, the word *timber* is often used to designate the larger beams of a structure although these beams are ready for use. We will first consider the timber in its natural condition, study its manner of growth, the different classes of trees, the defects which are to be found in this material and their causes, the way in which timber is converted into lumber, and pass on to a consideration of the various kinds of timber, studying the characteristics of each both in its natural state and after it has been prepared for use.

TIMBER IN ITS NATURAL STATE

CLASSES OF TREES

There are in general four kinds of trees from which timber suitable for structural purposes may be obtained, which differ from each other in their manner of growth and in the details of their structure, as well as in their adaptability to building work, but of these only two, the so-called broad-leaved trees and the needle-leaved trees, yield timber used in any great quantity for building. The other two are suitable for structural work but for one reason or another have not been extensively utilized as yet except in the immediate neighborhood of the places where they grow. This is especially true of the bamboos, which grow in abundance in China and the Philippine Islands and are there used extensively for building purposes, but which have never as yet been introduced into other countries, although the wood has certain characteristics which might make it very suitable for use in some locations, and the tree could probably be made to grow in any warm climate such as that of the southern states. There is another class of tree of which the palms are the most well-known representatives, but the use of the lumber cut from these trees is very limited.

Manner of Growth. There is a marked difference between the four classes of trees mentioned above in regard to their manner of growth. The palms and bamboos are somewhat similar and are known as endogenous trees, differing from the broad-leaved trees and the conifers which are known as exogenous trees. The endogens, to which family also belong cornstalks and certain kinds of grasses, increase from the inside and do not usually have a covering of bark. The wood is soft in the center of the trunk and becomes hard toward the outside. The soft interior of the stem sometimes is found to be missing entirely, leaving a hollow sort of tube, but this is true of the bamboos only, the palms being solid. The wood of these trees is composed of a multitude of cells or pockets like that of the exogenous trees, but the end of a log which has been cut does not show the rings which we see at the end of a log cut from a broad-leaved tree or a conifer, Fig. 1. Instead we see a series of dots of a darker color than the general surface, the difference being due to the different ways in which the two kinds of trees grow.

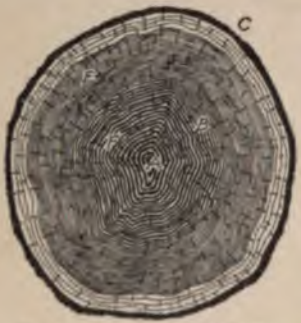


Fig. 1. Log Section of Conifer Showing Age Rings

The exogenous trees, to which class belong the broad-leaved trees and the conifers, increase from year to year both in height and in size of trunk. The increase in height and in the length of the branches is the result of a sort of extension process which takes place at the ends of all the small offshoots as well as at the extreme end of the main trunk of the tree. A bud is first formed at each of these places and speedily develops into a small twig, at first quite soft and with a covering of thin skin. In the course of time the skin gets harder and darker in color and the woody tissue inside gets firmer, while the extension process continues to take place at the end. Thus the branch or trunk of the tree becomes each year a little longer but any particular point on the branch remains in the same position with relation to the ground or to the parent trunk or branch. While the lengthening process is going on, another and a different kind of growth is taking place. The fluid known as sap is continually passing up and down between the roots of the tree and the leaves, and each year a new layer of wood is formed on the outside of the trunk and branches underneath the bark. Thus a cross section of the trunk of an exogenous tree presents a series of rings beginning at the center, where there is a small, whitish substance called pith, and extending to the outside where there is a covering of bark. In Fig. 1, *A* is the pith, *B* is the woody part of the tree, and *C* is the bark. The arrangement of the wood in concentric rings is due to the fact that it was formed gradually, one layer being added each year, and for this reason the rings or layers are called annual rings. It is interesting to note that the age of the tree may usually be determined with a fair degree of accuracy by counting the number of layers which appear on the cross section. The width of the annual rings varies from one-fiftieth of an inch to one-eighth of an inch according to the character of the tree and the position of the ring with relation to the center. In general, it may be said that the widest rings are to be found nearest the center or pith and that they grow regularly narrower as they approach the outside or bark. They are also wider at the bottom of the tree than at the top. The rings are very seldom circular or regular in form, but follow the contour of the tree trunk.

The wood nearest to the center of the tree where the pith is located is considerably harder and denser, as well as darker in color, than that which is on the outside nearer the bark. This wood is called heartwood to distinguish it from the other and softer wood which is called sapwood. The reason why the heartwood is harder and denser than the sapwood is that it is older and has been compressed more and more each year as the tree has increased in size, so that the pores have gradually become filled up. The sapwood is soft and of a lighter color than the heartwood showing that it has been more recently formed. The time required to transform the wood from sapwood to heartwood varies from nine to thirty-five years, according to the nature of the tree, and those trees which perform this hardening in the shortest time usually yield the most durable timber. It is not certainly known whether the change from sapwood to heartwood takes place ring by ring and year by year or whether sections of the trunk consisting of a number of rings change at the same time, but it is probable that the latter process is what really takes place, indeed there seems to be evidence to show that not even the whole of each ring changes at one time, but that part of a ring may remain sapwood after the remainder has become heartwood.

In addition to the annual rings, there are to be seen on the cross section of any log other lines which run from the center toward the bark at right angles to the annual rings. These are called medullary rays. Usually they do not extend to the bark, but alternate with others which start at the bark and run in toward the center but are lost before they reach the pith. This is shown at *E* and *F* in the figure. The medullary rays are much more pronounced and the structure of the wood is much more complicated in the broad-leaved trees than in the conifers, the structure of which is comparatively simple with most of the fibers running up and down in the direction of the growth of the tree. Thus, the wood of the pines and other conifers splits very much more easily than that of the oaks, chestnuts, and other broad-leaved trees.

Medullary rays are sometimes called pith rays and are caused by fibers or bundles of fibers which run at right angles to the others. It is the pith rays which appear as smooth, shiny spots or blotches in woods which have been quarter sawed. This will be explained later when dealing with the conversion of timber from its natural state into planks and other shapes ready for the market.

Details of Wood Structure. If a piece of wood were to be examined carefully under a microscope it would be seen that it was a composite substance, made up of a great number of very small fibers, and that these fibers were not solid but were so many little tubes or cells arranged together in a more or less complicated manner according to the kind of wood. Thus a piece cut from one of the needle-leaved trees would be seen to be much more simple and regular in arrangement than a piece cut from one of the broad-leaved trees. Both kinds of wood are composed of bundles of these fibers or tubes running parallel to the stem of the tree which are crossed by other fibers running at right angles to the first ones and binding the whole together. The cross fibers are much more numerous in the wood of the broad-leaved trees than in that of the conifers, and it is these fibers which appear on the cross section of a log as pith rays. There are also to be seen through the microscope a few resin ducts and other special fibers scattered through the wood. It is said that in pine more than 15,000 fibers occur on a square inch of section so that each one is very small and they can not be distinguished without the aid of a powerful microscope. The general arrangement is shown in Fig. 2, in which *AA* are the fibers parallel to the trunk of the tree and *BB* are the cross fibers. It will be noticed in this figure that the more numerous the cross fibers, the more thoroughly the wood will be tied together, and the harder and tougher it will be; also that it will split much more readily if there are a few cross fibers than it will if there are many. Thus the most important characteristics of timber are directly dependent on the structure of the wood.

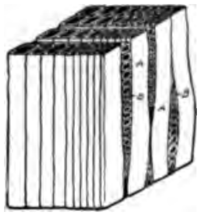


Fig. 2. Diagram of Pine Wood Fibers Magnified

Grain. The arrangement of the fibers which go to make up a piece of timber give to it certain characteristics which are described as different conditions of the "grain" of the wood, the word "grain" being used as a substitute for the word fiber. Thus "across the grain," means at right angles to the general direction of the fibers; "along the grain," means parallel to the direction of the fibers. In like manner woods are said to be "fine grained," "coarse grained," "cross grained," or "straight grained," these terms being used to indicate the relation of the fibers to each other and to the general direction of the growth of the tree. The wood is said to be fine grained when the annual rings are relatively narrow so as to show a large number of fine lines on a cross section of the log, and it is said to be coarse grained when the rings are wider so as to show a smaller number of coarser lines on the cross section of the log. Woods which are fine grained are generally harder and denser than those which are coarse grained and they can be made to take a high polish, while with the others, as a rule, this is not possible. Fine-grained woods are also said to be close grained. When the fibers are straight and parallel to the direction of the trunk of the tree, the wood is said to be straight grained, but if they are twisted so as to be spiral in form, not growing straight but following around the trunk of the tree, the wood is said to be cross grained. In Fig. 3, are shown three pieces of timber of which *A* is *absolutely cross grained, B* is *partially cross grained,* and *C* is *straight grained.* As examples, it may be mentioned that hemlock is coarse grained and usually cross grained, while white pine is close grained, although soft, and is usually straight grained. Most of the hard woods are fine grained.

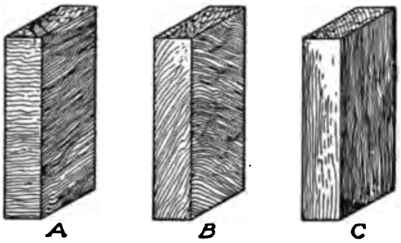


Fig. 3. Blocks Showing Cross Grained, Partially Cross Grained, and Straight Grained Wood

Defects in Wood. The fact that timber is not a manufactured material like iron or cement but is a natural product which has been formed by years of growth in the open where it has been all the while exposed to various adverse conditions of wind and weather, make it peculiarly liable to defects of different kinds, most of which can not be corrected and which render much of it unsuitable for use in construction. Moreover timber is not homogeneous like iron and steel products, in other words, it can not be safely assumed that several pieces of timber, even if they are cut from the same log, will have similar characteristics or will act in nearly the same way under the same conditions. Each piece of timber must be judged by itself and must be subjected to a very careful inspection if it is to be used in an important position with satisfactory results. Such inspection will often reveal some hidden weakness or blemish which is sufficient to warrant the rejection of the piece as not good enough for the particular purpose for which it is intended, and such weaknesses or blemishes are known as defects.

Most of the defects which render timber unsuitable for building purposes are due to irregularities in the growth of the tree from which the timber has been taken. These defects are known by various names as "heartshakes," "windshakes," "starshakes," and "knots." Other defects are due to deterioration of the timber after it has been in place for some time or even before the tree has been felled, among which are "dry rot" and "wet rot." The defects of the first class are defects of structure; those of the second class are defects of the material itself. It may also be said that the defects of the first class are permanent and are definitely defined, being caused by outside forces or conditions, thus the timber affected can be cut out and discarded leaving the rest of the piece perfectly sound and good, as the defect does not influence the timber near to it and does not spread. On the other hand the defects of the second class are in the nature of a disease which spreads from one part of a piece of timber to another and can even be carried from one piece of timber to another by contact.

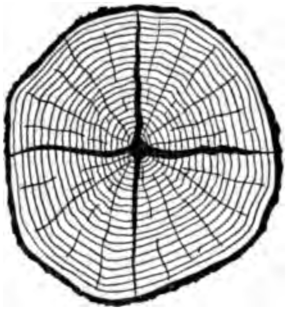


Fig. 4. Section of Log Showing Heartshake

Heartshake. As indicated by the name, heartshake is a defect which shows itself at the heart of the tree in the center of the trunk. The appearance of a cross section of a log affected by heartshake is shown in Fig. 4. There is first a small cavity at the center caused by decay, and flaws or cracks extend from this cavity outward toward the bark. The heartshake is most often found in those trees which are old, rather than in young, vigorous saplings; it is especially to be feared in hemlock timber.

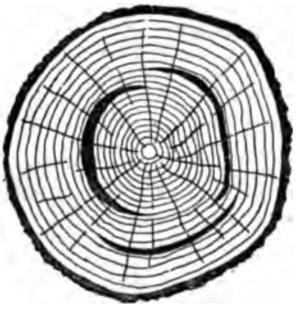


Fig. 5. Section of Log Showing Windshake

Windshake. The defect known as a windshake is so-called on account of the belief that it is caused by the racking and wrenching to which the growing tree is subjected by high winds. It is also claimed that it is produced by the expansion of the sapwood which causes a separation of the annual rings from each other, thus leaving a hollow space in the body of the trunk and following around between two of the annual rings. Fig. 5 shows the appearance of a windshake on the cross section of a log, and this appearance has given rise to the term *cupshake* which is sometimes used instead of *windshake*. The hollow space may extend for a considerable distance up the trunk of the tree. Windshakes are very frequently found in pine timber.

Starshake. A starshake is not readily distinguished from a heartshake, as the appearance of a log of wood affected by one is very similar to that of a log affected by the other, but the difference between the two is that while the center of a log affected by a heartshake is decayed so as to leave a large round cavity at this point, a log affected by a starshake shows no such decay at the center, but the cracks forming the star extend right across the cross section of the log, becoming wider as they approach the center and narrowing down to nothing near the bark, while all of the wood has the appearance of being sound.

Dry Rot. The defects which have been mentioned above are all of such a kind that they can be readily detected in the timber before it has been put in position in a structure, and, therefore, the use of the timber so affected may be avoided, but dry rot, while it is probably the most common and the most dangerous defect of them all, may start and spread rapidly in timber which appears to be absolutely sound when it is put in place. Dry rot is a disease which fastens itself upon the wood and spreads from one part of it to another, causing it to lose its strength and cohesive power and even to decay altogether. It may be readily seen that this process can lead to most serious results when it takes place in timber which is depended upon to carry heavy loads. Large beams and posts have been known to fail and thereby cause considerable damage solely because of dry rot, and others have been so weakened by the ravages of this disease that they have yielded when subjected to slight fires which would have had very little effect upon them if they had been sound.

The timber in which dry rot is most to be feared is that which is kept alternately wet and dry, while that which is always either entirely submerged in water or absolutely dry appears to be able to last indefinitely without a sign of the disease. For this reason wood piles should always be cut off below the water level. Decay takes place very rapidly when the wood is in a confined position where the gases can not escape. The ends of beams buried in brickwork and the ends of posts fitting into iron caps and bases are examples of such cases, and special precautions should be taken to allow the air to circulate freely around such woodwork wherever this is possible. Woodwork which is in contact with wet or damp materials, such as wet concrete or masonry in which the mortar has not dried out thoroughly, is peculiarly liable to dry rot. Wood flooring laid on top of newly-placed concrete slabs and immediately covered with some other substance has been known to rot very quickly. It is also noticeable that this form of decay seems to be hastened by warmth and is more common in the southern climates than in the northern. It may be prevented by introducing into the timber certain salts such as the salts of mercury, also by heating the wood to a temperature above 150° F. and keeping it at that temperature. As precautionary measures, all wood should be thoroughly seasoned before being painted, as good ventilation as possible should be provided for it, and it should be kept from contact with anything from which it can absorb moisture. Posts should have a hole about one and one-half inches in diameter bored through them from end to end, and other holes near each end bored through them crosswise, so as to provide for the free circulation of air in the interior of the post.

Wet Rot. There is another form of decay which affects wood in a manner somewhat similar to dry rot, but which takes place in the growing tree. It is known as "wet rot" and is caused by the wood becoming saturated with water which it may absorb from a swamp or bog. Wet rot may be readily communicated from one piece of wood to another by contact so that it is apt to spread rapidly.

Knots. Knots are more or less common in all timber, and consist of small pieces of dead wood which occupy a place in the body of the log with sound wood all around them. These bits of dead wood have no connection with the living wood about them, so that in the course of time they work loose, and when the log is sawed up into boards the pieces of dead wood fall out leaving round or irregular-shaped holes. Knots are formed at the juncture of the main tree trunk with branches or limbs, while such branches are still young and green. At such points the fibers of the main trunk, near the place where the branch comes in, do not follow straight along up the trunk, but are turned aside so as to follow along the branch as shown in Fig. 6. Frequently such a branch is broken off near the trunk of the tree when it is still young, while the tree itself continues to grow and the trunk increases in size until the end of the branch which was left buried in the main trunk is entirely covered up. Meanwhile the end of the branch dies and a knot is formed. The presence of a limited number of knots will not harm a piece of timber which is subjected to a compressive stress so long as they remain in place and do not drop out, but they very greatly weaken a piece subjected to a tension stress or used as a beam. Knots always spoil the appearance of woodwork which is to be polished.

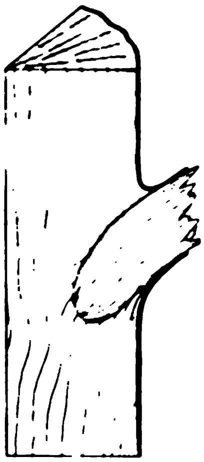


Fig. 6. Section Showing Formation of a Knot

The defects heretofore considered result from the natural growth of the tree and are not attributable to the handling of the timber after it has been cut, but there are several classes of defects which are caused by the seasoning of the timber and which have little or nothing to do with the growth of the tree. Among these are the actions known as "warping" and "checking."

Warping. This is the result of the evaporation or drying out of the water which is held in the cell walls of the wood in its natural state, and the shrinkage which naturally follows. If wood were perfectly regular in structure, so that the shrinkage could be the same in every part, there would be no warping, but wood is made up of a large number of fibers, the walls of which are of different thicknesses in different parts of the tree or log, so that in drying one part shrinks much more than another. Since the wood fibers are in close contact with each other and interlaced, thus making the piece of wood rigid, one part can not shrink or swell without changing the shape of the whole piece, because the piece as a whole must adjust itself to the new conditions; consequently the timber warps.

In Fig. 7, if the fibers in the lower portion of the piece near the face *CDG* happen to have, on the average, thicker walls than those in the upper portion, near the face *ABFE*, the lower part will shrink more than the upper part. The distance *CD*, originally equal to the distance *AB*, becomes smaller and the shape of the whole piece changes as shown in Fig. 8.

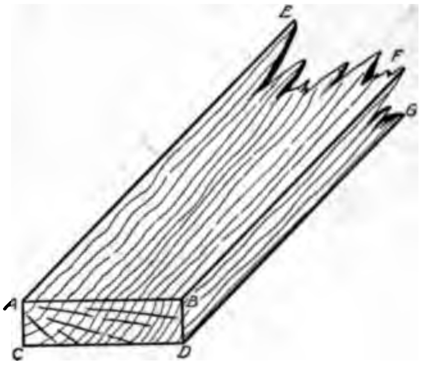


Fig. 7. Straight Board

The only way in which warping can be prevented is to have the timber thoroughly dried out before it is used, as after it is once thoroughly seasoned it will not warp unless it is allowed to absorb more moisture. All wood which is to be used for fine work, where any warping after it is in place will spoil the appearance of the entire job, must be so seasoned, either in the open air or in a specially prepared kiln.

The wood of the conifers which is very regular in its structure shrinks more evenly and warps less than does the wood of the broad-leaved trees with its more complex and irregular structure. Sapwood, also, as a rule shrinks more than does heartwood.

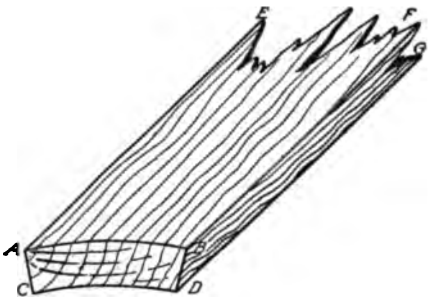


Fig. 8. Warped Board

Checks. Another defect which is caused by the drying out of the timber and the consequent shrinkage of the cell walls is what is known as checking. In any log of wood there is always opportunity for shrinkage in two directions, along the radial lines following the direction of the medullary rays, and around the circumference of the log following the direction of the annual rings. If the wood shrinks in both directions at the same rate, the result will be only a decrease in the volume of the log, but if it shrinks more rapidly around the circumference of the log than along the radial lines, the log must develop cracks around the outside as shown in Fig. 9. Such cracks are called checks. In timber which has been prepared for the market they show themselves in the form of cracks which extend along the faces of solid squared timbers and boards, seriously impairing their strength. Fig. 10 shows checks as they would appear in a square post or column.

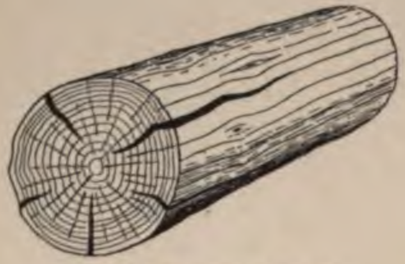


Fig. 9. Log Showing Checks

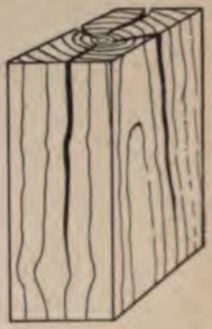


Fig. 10. Finished Timber Showing Checks

Conversion of Timber into Lumber. Lumber may be found in lumber yards in certain shapes ready for use, having been cut from the logs and relieved of their outside covering of bark. The cutting up of the logs is done in the mills by machinery and there are various methods in use for transforming the logs into boards, planks, and heavy timbers. The method of cutting the log determines the appearance of the wood when finished and also affects it in other ways.

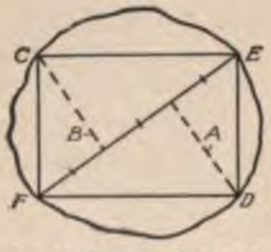


Fig. 11. Economical Method of Cutting Logs

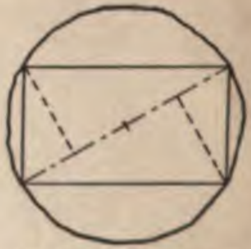


Fig. 12. Another Method of Cutting Logs

If the log is to be squared off so as to form only one heavy beam or post, a good rule to follow is to divide the diameter into three equal parts and then to draw perpendiculars to this diameter at the division points one on each side of the center, as shown at *A* and *B* in Fig. 11. The points *C* and *D* in which these perpendiculars to the diameter cut the circumference of the log, together with the points *E* and *F* in which the diameter cuts the circumference of the log, will be the four corners of the timber. The lines joining these points will give an outline of the timber, which will be rectangular and will be found to be the largest and best timber which can be cut from the log. Another good rule is to divide the diameter of the log into four equal parts and to proceed in the same way as described above, using the outside quarter points from which to draw the perpendiculars as shown in Fig. 12. This method will give the outlines of a stiffer beam than the one described above, but there will be more waste from the log and the beam will not be on the whole as strong as the other.

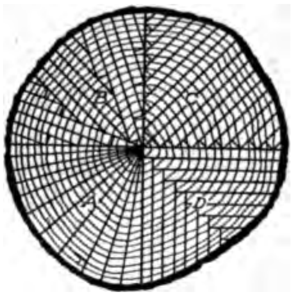


Fig. 13. Method of Cutting Planks from a Log

In Fig. 13 are shown several different methods of cutting planks from a log. First it is divided into quarters, and the planks are cut out as shown in the figure, there being four ways in which the work may be done. All of the four methods shown may be said to give what is called quarter-sawed lumber since the log is first cut into quarters, but that shown at *A* is the best. All of the planks are cut radiating from the center of the log and there will be no splitting or warping, but the method is very expensive, as all of the planks have to be squared up afterward and there is much waste as a result. A fairly good method is that shown at *B* where the planks are nearly along radial lines and may be much more easily and cheaply cut out than can those shown at *A*. The method shown at *C* is a common one and leads to fairly good results, although only the plank nearest the center is on a radial line. It is practically as good a method as that shown at *B* and is much more simple. The method shown at *D* is not so good as the others, as planks cut out in this way are very liable to warp and twist. If the silver grain, caused by cutting of the medullary rays is desired, the planks must be cut as shown at *A*, *B*, or *C*.

Planks are sometimes simply sliced from the log as shown in Fig. 14, without first dividing it into quarters, but this is the worst possible way of cutting them, as the natural tendency of the timber to shrink causes the planks to curl up as shown in Fig. 15. It is almost impossible to flatten them out again, and they can not be used in that condition.

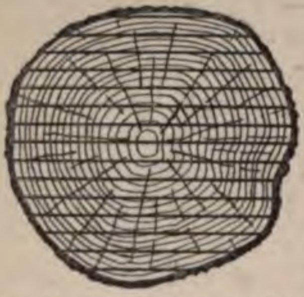


Fig. 14. Method of Slicing a Log

There is another method of cutting up a log which has been introduced more recently than the others, and which is known as the "rotary cut." It consists in placing the log on a movable carriage which keeps it whirling rapidly about its longitudinal axis, at the same time bringing it up against a long stationary knife which catches the log and peels off strips around the circumference of any desired thickness. This method is used extensively in the preparation of wood to be used as veneers, and in the case of many kinds of wood the figure is brought out to better advantage in this way than is possible with any other method.

Waney Lumber. When a log of wood has been sawed up into boards, each board is apt to have along the edge a strip of the bark which was originally on the outside of the log, and the edges will not be square with the face of the board, owing to the cylindrical shape of the log. Such boards should be squared up by having the rough edges to which the bark adheres trimmed off. But sometimes the bark alone is stripped off, leaving the boards with the edges not square with the face. Such boards are said to be waney, and very often specifications state that no waney lumber shall be employed on the work. The pieces which are cut off when waney boards are trimmed in order to square them up are called "edging" and are used to make laths.

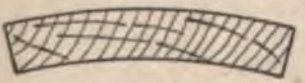
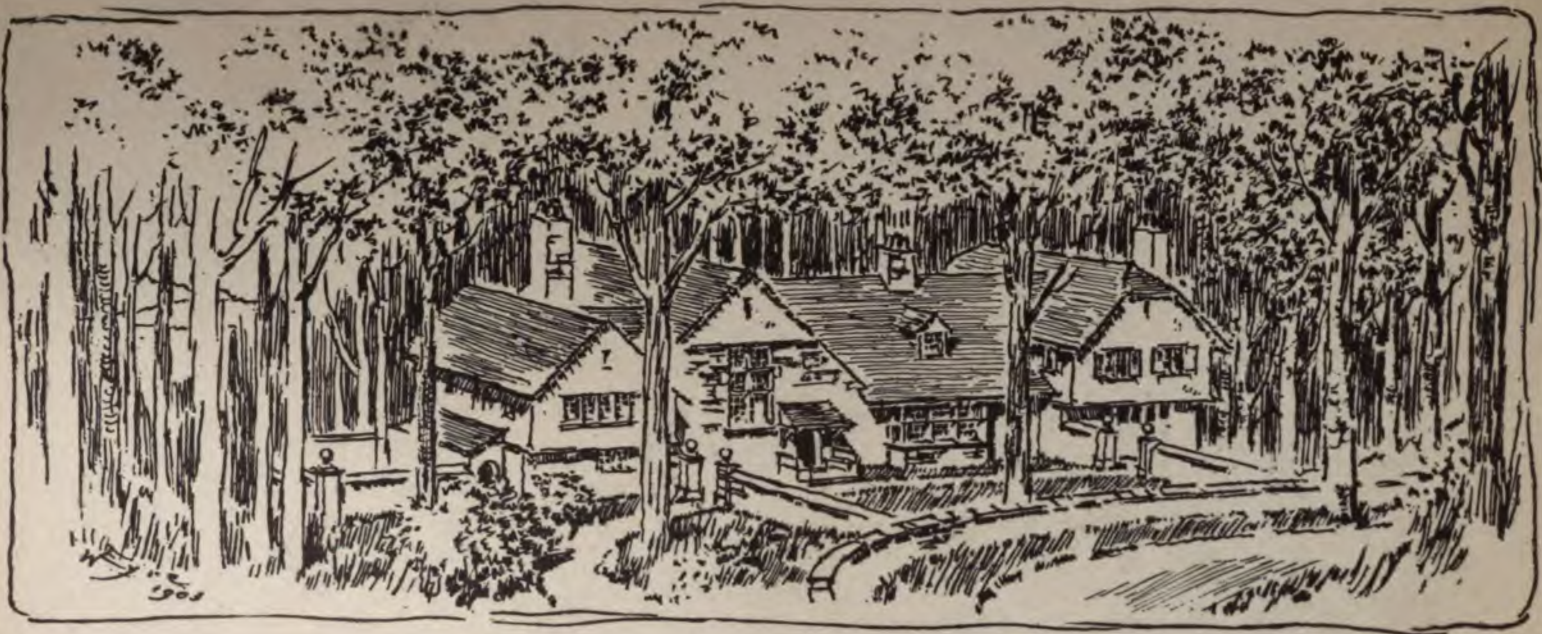


Fig. 15. Slicing Logs Gives Warped Lumber

Slabs. The pieces known as slabs are those which are left over after a log has been sawed up into boards. In cross section they are of the shape of a half moon, and are covered with bark. They are useless except for laths or fuel.



HOUSE AT TUXEDO PARK, N. Y.

Wilson Eyre, Architect, Philadelphia and New York

Plans and Rear Elevation of this House are Shown on Page 42.

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VARIETIES OF TIMBER

Although there are a great many different kinds of trees growing in different parts of the world, only a comparatively small number of them yield wood which is used to any great extent in building work. These differ very much among themselves, each variety possessing certain characteristics which render it especially suitable for use in one part of a building, while the same peculiarities of growth or of texture may make it unfit for use in another.

For use in places where the timber must be partly buried in the ground a wood is required which will be able to withstand the deteriorating effects of contact with the earth, and for this purpose chestnut, white cedar, cypress, redwood, or locust may be used.

For light framing is needed a cheap, light wood, as free as possible from structural defects, such as knots and shakes, and one which can be readily obtained in fairly long, straight pieces. Spruce, yellow pine, white pine, and hemlock all satisfy these requirements fairly well, spruce being perhaps a little better than the others, and more popular.

For heavy framing, such as trusses, girders, and posts, a timber is needed which is strong, and which can be obtained in large, long pieces. Georgia pine, Oregon pine, and white oak may all be used for such work, and also Norway pine and Canadian red pine. White oak is the timber which was always used for framing in the old days, but is too expensive to be used with profit for such work now. The timber most commonly used today is the Georgia pine.

A wood which can be easily worked and which will also be able to withstand the deteriorating effects of the weather is in demand for the outside finish. White pine is usually selected for this purpose, although cypress and redwood are also suitable and are used to some extent. The same woods are used for shingles, clapboards, and siding, with the addition of cedar and spruce for shingles, and Oregon pine and spruce for siding.

For the interior finish is chosen a wood which will give a pleasing appearance when finished and which will take a high polish, while for floors, hardness, and resistance to wear are the additional requirements. For floors, oak, hard pine, maple, and birch are good, while for the remainder of the interior finish white pine, cypress, and redwood for painting, or any of the hard woods such as ash, cherry, oak, walnut, or mahogany, may be selected.

Some of the more important varieties of timber used in Carpentry will now be mentioned, and a brief description of each variety will be given in order to convey an idea of their characteristics and the part of the world from which they come.

Conifers or Needle-Leaved Trees. These trees are found mostly in the North, where they form large forests from which are taken the large quantities of timber of this kind used every year. The wood is very popular for use in rough building construction or for finished work which is to be painted, as it is very regular in structure and consequently easy to work; it can be obtained in large, long, straight pieces, and is light and strong. The demand for woods of this kind is considerably in excess of the demand for the harder woods. The trees are mostly but not all evergreen, and bear needles instead of leaves, together with the cones, from which they are called conifers.

Cedar. The wood known as cedar has long been used in construction, as is illustrated by the references in the Bible to the "Cedars of Lebanon" from which the Temple of Solomon was constructed. The wood in use at the present day called cedar is, of course, not of exactly the same species as was that used in the famous temple, but it is of the same family and possesses the same general characteristics. There are two kinds, the red cedar, and the white cedar, which differ from each other principally in color, the white cedar being grayish brown, while the red cedar is reddish brown.

There are several different kinds of white cedar in use, of which one is known as the canoe cedar. The wood is not very strong, but is light and soft, possessing considerable stiffness and a fine texture. In color it is as mentioned above, grayish brown, the sapwood being, however, of a lighter color than the heartwood. It seasons quickly, is remarkably durable, and does not shrink or check to any great extent. The wood is used in building construction, principally for shingles, for which purpose its durability in exposed positions makes it especially valuable. It is also used for posts and ties.

The trees are usually scattered among others of different kinds, forming occasionally, however, forests of considerable size. They are to be found all through the northern part of the United States and in Canada, also on the Pacific Coast in California, Oregon, and Washington. They also grow to some extent in the southern states. Some of the trees are of small or medium size, while others are very large, especially the canoe cedar of the Northwest.

In addition to the white cedars, there are the red cedars, which are similar to the white cedars but differ from them slightly in the color of the wood, which is reddish brown instead of grayish brown. The red cedars are also of somewhat finer texture than the white cedars. Red cedar is used but little in building construction, but is used extensively in cabinet work for chests and closets which this wood is supposed to render proof against moths. The wood is also used for the making of lead pencils and for cigar boxes, large quantities of timber being used for these purposes every year.

Cedar trees are sometimes subject to a disease similar to wet rot, which attacks the growing tree. This disease does not, however, render them unfit for use in every case, as the disease often disappears as soon as the tree has been cut down, and trees have been known to yield timber which has endured for long periods, although the living tree itself was diseased.

Redwood. There is a wood which greatly resembles good red cedar and which is found only in the State of California. One species of this tree grows to an enormous size and is famous on this account, but this is not the one which yields the lumber used for building purposes, which is known as the common redwood. The wood is used for cheap interior finish and for shingles, also for use in heavy construction, thus serving nearly the same purposes as does hard pine in the eastern states. Redwood is light, and not very strong, but on the other hand, it is remarkably durable, resisting fire to a considerable extent. It is easy to work and will take a polish so that it is valuable for inside finish, and some of the wood has a wavy grain which adds greatly to its finished appearance. This wood is known as "curly" redwood. In color the heartwood is red, but the sapwood is nearly white, with the wood between them varying in color and averaging a rich reddish brown. The grain is usually straight and the wood is solid and dense in structure but the grain is more or less coarse in appearance.

Cypress. This is a wood which is somewhat similar to white cedar in appearance, and which grows in quantities only in the southern states, where it may be seen in great swamps with the roots very often partially exposed. Although there are a great many varieties, they are similar in their general characteristics, differing only in quality. "Gulf Cypress," growing near the Gulf of Mexico, is the best. "Bald Cypress," is a name which has been applied to these trees on account of the fact that they show no leaves in winter and this gives them a peculiar appearance. When the wood is dark in color it is called "Black Cypress," and in some localities yellow and red cypress are spoken of. The growing trees are often affected by a disease which leaves the wood full of small holes which look as though they might have been made by driving pegs into the wood and then withdrawing them. Cypress wood affected in this way is called "peggy."

Hemlock. There are two varieties of hemlock, one found in the northern states, from Maine to Minnesota, and along the Alleghenies southward to Georgia and Alabama, while the other is found in the west from Washington to California and eastward to Montana. The eastern tree is smaller than the western and its wood is lighter, softer, and generally inferior. The trees are evergreen and bear cones, with flat, blunt needles, and they usually grow alone or in small groups in the midst of forests of other trees.

The timber is of a light, reddish-gray color, fairly durable, but shrinks and checks badly, and is coarse, brittle, and usually cross grained. It is hard to work but will hold nails very well. The wood is sometimes used for cheap framing, and has been used for cheap interior finish, but it is so liable to imperfections, such as windshakes and starshakes, that it is not the best wood to use for these purposes, although the increasing cost of the better woods will no doubt force it into more general use. Hemlock is most frequently used for rough boarding and sheathing.

Spruce. Another evergreen and cone-bearing tree which furnishes great quantities of lumber to the market every year is the spruce. There are three kinds of spruce, *white*, *black*, and *red*, of which the white spruce and the red spruce are the varieties commonly found on the market. The white spruce is scattered throughout all of the northern states, along the streams and lakes, the largest varieties being found in Montana. The black spruce is found in Canada and in some of the northern states. It is distinguished from the other varieties by its leaves and bark only, the foliage being much darker in color than that of the white spruce, while the cones remain in place for several years, a much longer time than do those of the white spruce. The red spruce is sometimes known as Newfoundland red pine and is found in the northeastern part of North America. It is used very extensively in northern New England where it serves as a substitute for soft pine, and large quantities of it are used up every year for pulp wood.

The leaves of the spruce are single and have sharp points at the ends. They are short and four-sided and are arranged on the stem so as to point in all directions. The cones hang downward, while those of the fir trees point upward.

Spruce trees have many natural enemies and numbers of the trees are destroyed before they reach the market. Large quantities of fallen tree trunks are to be found in the forests, blown down by the wind alone during heavy wind storms, or so weakened by the ravages of insects that they have fallen from their own weight. There is a beetle which attacks these trees especially, and which causes great damage, while very often the same trees are attacked by various kinds of fungous growths.

Spruce timber is of a light color, very nearly white except the heartwood which has a reddish tinge. It is very dense and compact in structure and straight grained. The wood is light and soft, fairly strong for a soft wood, but not very durable when exposed. It is very resonant and is frequently used for sounding boards on this account. It can not be obtained in large sizes, but it is considered by many to be the best framing timber available, except the pines.

Pine. This is the timber which has been used in building construction to a greater extent than any other except perhaps oak. It is peculiarly fitted for the purpose as it has grown in great abundance all over the United States and possesses all of the most desirable characteristics of a good building material, being strong, but at the same time light in weight and easily worked, elastic, and very durable. The tree is almost always a large one with branches starting at a considerable distance from the ground. It has a smooth, straight trunk, evergreen, needle-shaped leaves, of varying length, and cones.

There are two distinct classes of pines used in building work, the soft and the hard pines, both of which are found in large quantities. The softer varieties are used for outside finish of all sorts, and the harder varieties for heavy framing and for flooring. The ease with which the soft-pine lumber can be cut and shipped to the market, makes it the most popular wood in use at the present time. It is of uniform texture and nails without splitting, seasons very well, and does not shrink so much as the harder pines, will take paint and is very durable. The wood is white in color, straight grained, and has few knots. The hard pines furnish the strongest timber in use for building, with the exception of oak, which is now almost too expensive to be used for heavy framing. The pieces can be obtained in large sizes and great lengths and the wood is very hard, heavy, and durable, at the same time being tough. In color it is yellow or orange, the sapwood being of lighter color than the heartwood.

There are many different kinds of pines, which are recognized in different parts of the country under various names, but there are five general classes into which the species is commonly divided, though the same timber may be called by different names in two different localities, as will be seen.

(1) The term "hard pine" is used to designate any pine which is not white pine, a classification which is very general, though it is often seen in works on Carpentry and in specifications.

(2) "White pine," "soft pine," and "pumpkin pine," are terms which are used in the eastern states for the timber from the white-pine tree, while on the Pacific Coast the same terms refer to the wood of the sugar pine.

(3) The name "yellow pine," when used in the northeastern part of the country, applies almost always to the pitch pine or to one of the southern pines, but in the West it refers to the bull pine.

(4) "Georgia pine" or "longleaf yellow pine," is a term used to distinguish the southern hard pine which grows in the coast region from North Carolina to Texas, and which furnishes the strongest pine lumber on the market.

(5) "Pitch pine" may refer to any of the southern pines, or to pitch pine proper, which is found along the coast from New York to Georgia and among the mountains of Kentucky.

Of the soft pines there are two kinds, the white pine and the sugar pine, the latter being a western tree found in Oregon and California, while the former is found in all the northern states from Maine to Minnesota. There is also a smaller species of white pine found along the Rocky Mountain slopes from Montana to New Mexico.

There are ten different varieties of *hard pine*, of which, however, only five are of practical importance in the building industry. These are the "long-leaf southern pine," the "short-leaf southern pine," the "yellow pine," the "loblolly pine," and the "Norway pine."

The long-leaf pine, also known as the "Georgia pine" and the "long straw pine," is a large tree which forms extensive forests in the coast region from North Carolina to Texas. It yields very hard, strong timber, which can be obtained in long, straight pieces of very large size.

The loblolly pine is also a large tree but has more sapwood than the long-leaf pine, and is coarser, lighter, and softer. It is the common lumber pine from Virginia to South Carolina, and is found as well in Texas and Arkansas. It is known also by the names of "slash pine," "old field pine," "rosemary pine," "sap pine," and "short straw pine," and in the West as "Texas pine."

The short-leaf pine is much like the loblolly pine and is the chief lumber tree of Missouri and Arkansas. It is also found in North Carolina and Texas.

The Norway pine is a Northern tree found in Canada and the northern states. It never forms forests, but is scattered among other trees, and forms small groves. The wood is fine grained and of a white color but is largely sapwood and is not durable.

Fir. The fir tree yields timber very similar to spruce, and is often mixed in with spruce in the market. There are two kinds of fir trees, the western fir tree and the eastern fir tree, the first being known as the silver fir and the other as the balsam fir. All of the firs are evergreen, and bear cones which stand erect instead of hanging down. The wood is soft and not strong, being of a much coarser quality than ordinary spruce. It can be used in building work only for the roughest work in the case of the eastern fir, while the western fir is used more extensively but is not as good as spruce.

Tamarack. This is a wood which is very much like spruce in structure, but is hard and very strong, resembling hard pine in this respect. The tree grows in the northern part of the United States and Canada, both in the East and in the West, and also in Europe. Its true name is larch, but it has come to be known as tamarack, tamarack pine, and hackmatack. In the East the tree grows in wet places called tamarack swamps, but the tree in the West and in Europe thrives best in dryer soil, and grows more quickly under these conditions than in a swamp. The wood is used mostly for long straight timbers such as posts, poles, and quite extensively for piles. It has also been used a great deal for railroad ties. It is supposed to be very durable, and is well suited for use as ties or as piles, but it can not always be obtained now. It has never been used to any extent as sawn lumber, because the demand for the trunks for use as posts and poles has been so great that it did not pay to saw them up.

Broad-Leaved Trees. *Ash.* Ash is a wood which is frequently employed for interior finishing in public buildings, such as school houses, churches, and so forth, and also in the cheaper classes of dwelling houses. It is one of the cheapest of hard woods, and is used when it is desired to have a hard-wood finish and when the more expensive kinds of hard wood, such as oak, can not be afforded. The wood is somewhat like oak in texture and appearance, the difference being that ash is coarser, and the pith rays do not show. It is strong, straight grained, and tough, comparatively easy to work, elastic, and fairly durable. It shrinks moderately, seasons with little injury, and will take a good polish. The trees do not grow together in forests, but are scattered. They grow rapidly, and attain only medium height. Of the six different species found in the United States, only two, the "white ash," and the "black ash," are used extensively in building work. The first is most common in the basin of the Ohio River, but is also found in the North from Maine to Minnesota, and in the South, in Texas. The black ash is found from Maine to Minnesota, and southward to Virginia and Arkansas. There is very little difference between the two species. The black ash is also known as the "hoop ash," and the "ground ash."

Beech. This wood is not used to any great extent in Carpentry except in Europe, but is made up into tool handles, shoe lasts, and so forth, and is also used in wagon making and ship building. The tree grows freely in the eastern part of the United States and Canada and also in Europe. There are a number of different species and the tree is sometimes called by other names such as "ironwood," and "horn-beam." The wood is used for building work in the United States only occasionally for inside finish and is not a popular wood. It is heavy, hard, and strong, but of coarse texture like the ash. In color it is light brown, or white. It shrinks and checks during the process of drying out, and is not durable when placed in contact with the ground. It works fairly well, stands well, and will take a good polish.

Birch. Birch is a very handsome wood of a brown or red color and with a satiny luster. There are two kinds, the red birch and the white birch, but they are both taken from the same kind of tree, the difference being that the red birch consists of more and older heartwood, while the white birch is the sapwood or the younger heartwood. The trees are of medium size and form large forests. They are found throughout the eastern part of the United States and Canada, and in the extreme north. The distinguishing feature of the tree is the bark, which is famous because of its beauty and its usefulness for a number of purposes. This bark is white in color with long dashes of a darker color running around the tree trunk in a horizontal direction. It is water-tight and pliable, which made it useful to the Indians for the covering of their canoes. It was also used in ancient times, before the manufacture of paper, as a material to write upon. The bark has been used for a number of other purposes. The wood is used quite extensively for inside finish and floors, and to imitate cherry and mahogany, as it has a grain which is very similar to the grain of these woods. It takes a good polish, works easily, and does not warp after it is in place, but it is not durable when exposed to the weather.

Butternut. Butternut is really a branch of the family of walnuts, and differs from them only slightly. The wood is used to some extent for inside finish, and is cheaper than most of the other hard woods. It is light, but not strong, and is fairly soft. In color it is light brown. The trees, of medium size, are found in the eastern states from Maine to Georgia.

Cherry. Cherry is a wood which is frequently used as a finishing wood for the interior of dwellings and of cars and steamers, but, owing to the fact that it can be obtained only in narrow boards, it is most suitable for molded work, and work which is much cut up. The wood is heavy, hard, strong, and of fine texture. The heartwood is of a reddish brown color, while the sapwood is yellowish white. It is very handsome and takes a good polish, works easily, and stands well. It shrinks considerably, however, in drying. The timber is cut from the wild black cherry tree, not from the cultivated cherry tree. This tree is of medium size, and is found scattered among the other broad-leaved trees along the western slopes of the Alleghenies, and as far west as Texas. The fruit of the wild cherry is of a dark purple color, about the size of a large pea. When ripe it tastes slightly bitter. The bark of the tree also tastes bitter. Cherry is often stained to resemble mahogany, and sometimes birch is stained to resemble cherry.

Chestnut. The grain of chestnut somewhat resembles oak but it is much softer and coarser in texture and does not show the medullary rays which form the distinguishing feature of oak. Chestnut is used for cabinet work, for interior finishing, and sometimes for heavy construction. It is light, fairly soft, but not strong. The wood has a rather coarse texture, works easily and stands well, but shrinks and checks in drying. It is very durable and can be safely used in exposed positions. The tree grows in the region of the Alleghenies, from Maine to Michigan, and southward to Alabama. The wood is dark brown in color, with the sapwood a little lighter.

Elm. There are five species of elm trees in the United States, scattered throughout the eastern and central states. The trees are usually large and of rapid growth, and do not form forests. The timber is hard and tough, frequently cross-grained, hard to work, and shrinks and checks in drying. The wood has not been used very extensively in building, but has a beautiful figured grain, can take a high polish, and is well adapted to staining. The texture is coarse to fine, and the color is brown with shades of gray and red.

Gum. The wood of the gum tree has been used extensively for cabinet work, furniture, and interior finish. It is of fine texture and handsome appearance, heavy, fairly soft, yet strong. Its color is reddish brown. The wood warps and checks badly, is not durable when exposed, and is hard to work. It has a close grain, and some pieces are so regular that they have been stained to imitate black walnut and used as veneers for the manufacture of furniture and cabinet work. The species of gum tree, which yields timber of use in carpentry, is known as the sweet gum. It is of medium size, with a straight trunk. The trees do not form forests, though they are quite abundant east of the Mississippi River. The leaves have five lobes which are long and pointed, thus giving them a starlike appearance. The bark is very rough, and its resemblance in appearance to the skin of an alligator has caused the wood to be called "Alligator Wood" in some localities.

Maple. Almost all of the maple used in building work comes from the hard sugar maple, which is most abundant in the region of the Great Lakes, but which is also found from Maine to Minnesota and southward to Florida. The trees are of medium to large size and form quite considerable forests. They are so abundant in Canada that the maple is the national tree, and the national emblem is a maple leaf. The wood when finished presents a very pleasing appearance, and ranks as one of the best of the hard woods in this respect. It is heavy and strong, of fine texture, and often has a fine wavy grain which gives the effect known as "curly." Other defects which add to the beauty of the grain occur in what is called "blister" and "bird's-eye" maple. These defects are the result of twisting of the fibers which make up the woody structure of the tree, and the maples seem to show them more frequently than any of the other trees, though they sometimes are to be found in birch and various other woods. The color of the sapwood is a creamy white while the heartwood is tinged with brown. The lumber shrinks moderately, stands well, is easy to work, and is tough, but not very durable when subjected to exposure. The finished wood takes an excellent polish. It is most commonly employed for floors, and in other positions where a good wearing surface is required, as well as for ceiling and paneling, and other interior finish.

Oak. This is a wood which has probably been used more than any other kind in all classes of structures. In ancient times it was about the only wood in use both for the building of houses and for shipbuilding. Since the softer woods have become popular and oak has become somewhat less easy to get, its use has diminished to some extent, but it is still one of the most useful of woods. The trees grow freely all over the northern parts of Europe and America, extending as far south as the Equator, and have been particularly plentiful in the British Isles. There are about twenty different kinds of oaks to be found in various parts of the United States and Canada, but there are three distinctly different species, which are sold separately. These are the "white oak," the "red oak," and the "live oak." The red oak is usually more porous, less durable, and of coarser texture than the white oak or the live oak. The trees are of medium size and form a large proportion of all the broad-leaved forests. Live oak was once very extensively used, but has become scarce and is now expensive. Both the red oak and the white oak are used for inside finishing, but they are liable to shrink and crack and must, therefore, be thoroughly seasoned. They are of slightly different color, the white oak having a straw color while the red oak has a reddish tinge, so that they can not be used together where the work is to be finished by polishing. Oak is always best if quarter-sawed and it then shows what is known as the "silver grain." This is the result of the cutting of the medullary rays, and appears on the finished wood as a succession of splashes or blotches which are of lighter color than the rest of the wood and which glisten in the light.

Poplar. This wood is also known in the market as "white wood," "tulip wood," and sometimes as "basswood." The poplar, the whitewood or tulip tree, and the basswood are, however, three distinct kinds of trees, but the wood of each so nearly resembles that of the others as to be indistinguishable in the market and so it is sold under any one of these various names. The lumber yielded by the tulip tree and known commercially as whitewood is the best. This tree is a native of North America and grows freely all over the United States and Canada. There are a number of different varieties growing in various parts of the country. It is sometimes called "yellow poplar." The poplar or cottonwood is most common in the region of the Ohio basin, and grows in the western desert regions along the water courses. The tree is a large one and usually grows in small groups, not forming extensive forests. The basswood tree, also known as the linden, grows all over the eastern part of the United States and Canada, and in the middle west. The wood of all these trees is light, soft, free from knots, and of fine texture. In color it is white, or yellowish white, and frequently has a satiny luster. It can be so finished as to retain its natural appearance, but it is often stained to imitate some of the more costly woods, such as cherry. It is used extensively for cheap inside finish and fittings, such as shelving, and sometimes for doors, but it warps badly if it is not thoroughly seasoned, and will not stand exposure.

Sycamore. Sycamore is frequently used for finishing, and is a very handsome wood. It is heavy, hard, strong, of coarse texture, and is usually cross grained. It is hard to work, and shrinks, warps, and checks considerably. The tree is of large size and rapid growth, found in all parts of the eastern United States, and is most common along the Ohio and Mississippi rivers.

Walnut. There are a number of different kinds of walnut trees, of which only one or two, however, yield timber which is suitable for use in building construction. The best known trees are the "English walnut," the "black walnut," the "white walnut" or "butternut," and the "Circassian walnut." The English walnut grows in Europe, and is not very popular as a finishing wood, while it is too expensive to be used for rough lumber. Formerly great quantities of it were used in the manufacture of gun stocks, so much so as to create a demand for the entire supply. The black walnut is a native of North America, and until about thirty years ago it was used very extensively in the United States for interior finish and furniture, taking the place of oak for these purposes. During recent years, however, the wood has ceased to be popular, and is now very seldom used. This is partly due to the scarcity and consequent high price of the timber. It is a heavy hard wood of coarse texture and of a rich dark-brown color. Very handsome pieces having a beautiful figure may be selected for veneers for furniture and cabinet work. Although the wood shrinks somewhat in drying, it works easily, stands well, and will take a good polish. The tree is large and of rapid growth. It was formerly very abundant in the Allegheny region, and was found from New England to Texas and from Michigan to Florida. White walnut, or butternut, is somewhat like black walnut wood, but is of a lighter color and is not so pleasing when finished. Circassian walnut is beautifully figured, and is sometimes used for piano cases, and costly cabinet work, but it is very scarce and very expensive.

Laurel. The tree of this name which is most extensively used in building work is the California laurel, which grows on the Pacific

Coast and is seldom seen used in the eastern part of the country. The wood is hard, heavy, and strong, light brown in color, and of close grain. The sapwood is considerably lighter in color than the heartwood. The wood takes a very good polish and is quite genererally used on the Pacific Coast for cabinet work and interior finishing.

Osage Orange. This is a southern wood, growing in the Gulf States and seldom seen in the North. The tree is of medium size, bears fruit somewhat resembling an orange, and is protected by large thorns. The wood ranges in color from bright yellow or orange to brown and is hard and strong, though at the same time very flexible. It is very durable in damp places, and in positions where it comes in contact with the earth. The wood shrinks somewhat, and checks, but will take a good polish, and it is, therefore, used to some extent for interior finish, but its principal use is for poles and posts, piles, ties, etc.

Locust. The locust is a tree which yields wood valuable in construction on account of its great durability in exposed positions. The eastern tree is called the black locust, while the tree in the western states is known as the mesquite. There is a slight difference between the two trees, but they belong to the same family. The wood is hard, heavy, and strong, reddish brown in color, and close-grained. It was largely used in the past for long wood pegs called tree-nails and is now used wherever great durability is required.

Holly. This wood is very highly prized for use in inlaid work, both on account of its beautiful even grain, and on account of its clear white color. The American tree grows in all the eastern states where it attains to medium size. It is characterized by its evergreen foliage and its red berries. The wood is cream white in color, and moderately strong. It is easily worked, but is not durable and can not be exposed.

Imported Timber. Besides the woods which grow in the United States, a number of others are brought in from foreign lands for use in the best grade of public buildings and private residences. The most popular of these are the mahogany, rosewood, satinwood, French burl, and Circassian walnut.

Mahogany comes from Cuba and Mexico, and formerly was obtained also from Santo Domingo and Honduras. Other kinds of so-called mahogany are also obtained from Africa and India, and some come from South America. The wood is generally imported in the rough log and cut up by the purchasers as it is required. It is easy to work, will take an excellent polish, and stays in place very well if it is properly seasoned. The color varies from very light to deep red, which becomes darker and richer with age. There is also what is called white mahogany, which is golden yellow in color. The wood is very costly and can only be used for the best work. Generally it is used in the form of veneers.

Satinwood comes from both the East and the West Indies. It is hard and strong and very durable, but brittle and hard to work. It is so costly as not to be used for anything but the finest cabinet work, for which it is valued on account of its color, which is very light yellow, and its satiny luster. It takes a very good polish.

French burl comes from Persia, and *Circassian walnut* from near the Black Sea. Both of these woods are very expensive and can be used on that account only in veneers and only for the best work.

GENERAL CHARACTERISTICS OF TIMBER

In speaking of wood we are accustomed to use certain words to express our idea of its mechanical properties, or of its probable behavior under certain conditions. Thus we say that a wood is hard, or tough, or brittle, or flexible, and frequently we use these terms without having a clear understanding of just what they mean. A very brief discussion of some of these properties or characteristics of lumber will now be given in order that we may see what peculiarities of structure or of growth cause them.

Hardness. If a block of wood is struck with a hammer when lying on a bench, the hammer-head will make an impression or dent in the wood, which will be deeper or shallower according as the wood is soft or hard. A wood is said to be very hard when it requires a pressure of about 3,000 pounds per square inch to make an impression one-twentieth of an inch deep. A hard wood requires only about 2,500 pounds to produce the same effect. Fairly hard wood will be indented by a pressure of 1,500 pounds, and soft woods require even less. Maple, oak, elm, and hickory are very hard; ash, cherry, birch, and walnut are hard; the best qualities of pine and spruce are fairly hard, and hemlock, poplar, redwood, and butternut are soft.

Toughness. "Toughness" is a word which is often used in relation to timber, and implies both strength and pliability, such as is found in the wood of the elm and the hickory. Such timber will withstand the effect of jars and shocks which would cause other woods like pine to be shattered.

Flexibility. Timber is said to be flexible when it bends before breaking instead of breaking off short, or, in other words, a flexible wood is the opposite of one which is brittle. The harder woods, taken from the broad-leaved trees, are usually more flexible than the softer woods, taken from the cone-bearing trees. The wood of the main tree trunk is more flexible than that of the limbs and branches, and moist timber is more flexible than dry wood. Hickory is one of the most flexible woods.

Cleavage. Most woods split very easily along the grain, especially when the arrangement of the fibers is simple, as in the conifers. In splitting with an axe, the axe-head acts as a wedge and forces the fibers apart, so that usually the split runs along some distance ahead of the axe. Hard woods do not split so easily as do soft woods, and seasoned wood not so easily as green wood, while all timber splits most easily along radial lines.

CARPENTERS' TOOLS

Steel Square. It is not only important that the workman should know the character and usefulness of the various materials, but it is also essential that he should be familiar with the steel square, which is the universal tool used to lay out the material. Figs. 16 and 17 show one side of one of the common squares in general use. The three parts are distinguished by special names, the tongue, the blade, and the heel. The longer and wider arm is the blade, the shorter and narrower arm is the tongue, and the point where the two arms meet is called the heel.

The numerous applications of the tool are given in detail under the subject of "The Steel Square."

Saws. Another very important and much used tool, wherever wood working is done, is the saw, and so much depends upon its careful manipulation and intelligent use that it will not be out of place to devote a few pages to a consideration of the different kinds

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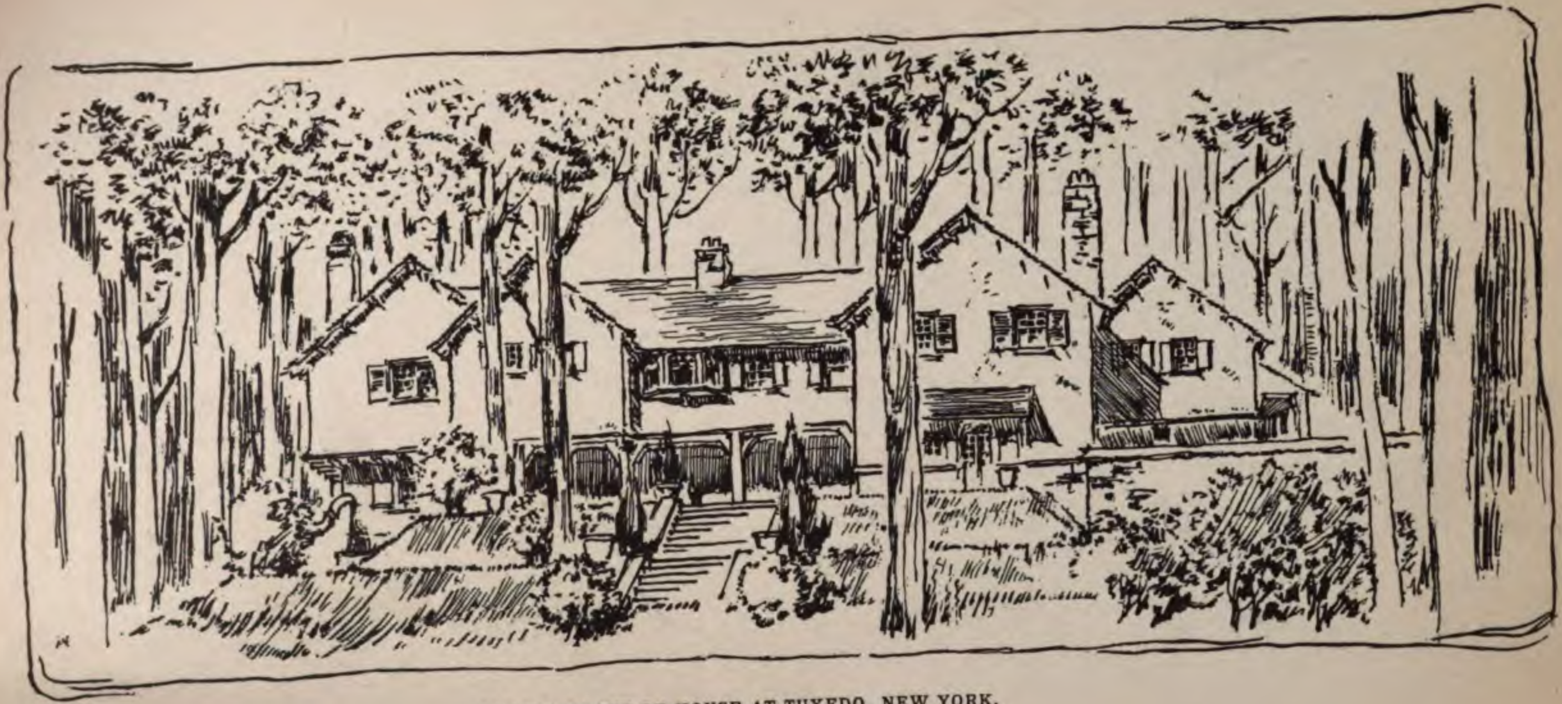
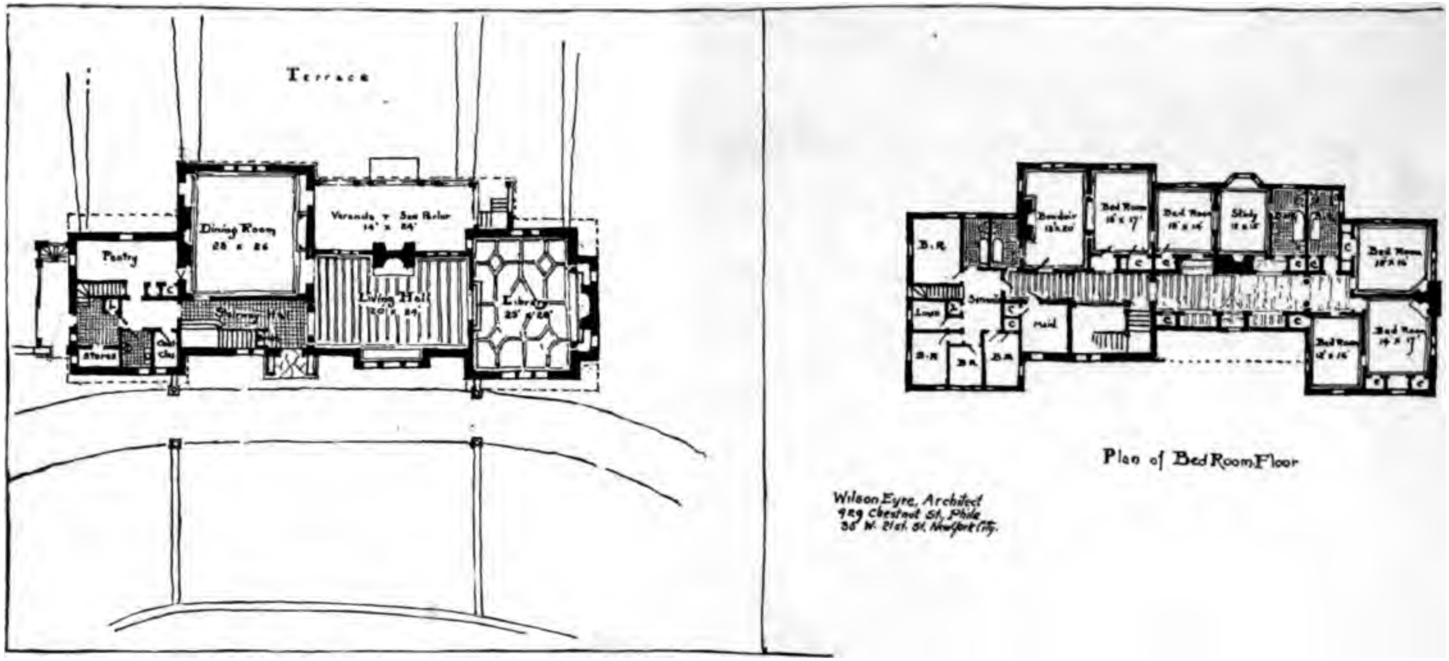


GARDEN FRONT OF HOUSE AT TUXEDO, NEW YORK.

Wilson Eyre, Architect, Philadelphia and New York

Exterior Walls of Rough-Cast on Wood Lath; Roofs of Shingles.
For View of Main Front of House, See Page 26.



HOUSE AT TUXEDO PARK, NEW YORK, FOR MR. HARLSTON DEACON.

Wilson Eyre, Architect, Philadelphia and New York

Built in 1903-04. Cost, about $30,000. For View of Front of House, See Page 26.

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of saws and their respective possibilities, as well as to their care and the way in which they should be chosen.

There are in general two kinds of saws, which differ from each other in the arrangement of the teeth, and which are intended, one for cutting wood in the direction of the grain, and the other for cutting wood at right angles to the grain. In order to cut the wood in the direction of the grain it is not necessary to cut through very many of the fibers, as the cut is, in general, parallel to them, but it is necessary rather to force the fibers apart without tearing them. Of course it is impossible to cut the wood without tearing the fibers to some extent, but this is the best way to make clear the difference in principle between the two kinds of saws, and an understanding of this difference is necessary in order to appreciate their construction and the proper care of them. The cutting of the wood across the grain, on the other hand, requires a tool made especially with a view to cutting through the fibers as quickly and as easily as possible.

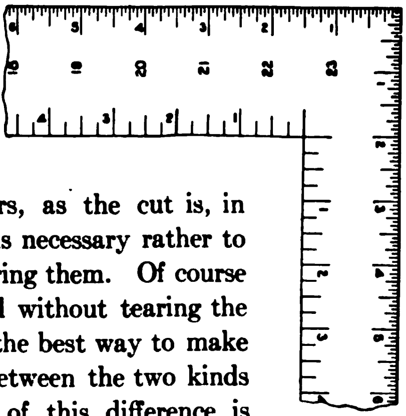


Fig. 16.
Steel Square

Besides these two there are various other special saws designed for a particular kind of work, such as the cutting out of key holes, the cutting of dovetails, the cutting of miters, and other operations required in joiners' or carpenters' work.

Rip Saw. This saw is designed for cutting along the direction of the grain of the wood, and from this comes its name, which suggests very clearly its purpose. Fig. 18 shows one of these saws, but the shape of the blade varies a great deal with different makers, and some people prefer one shape while others prefer another.

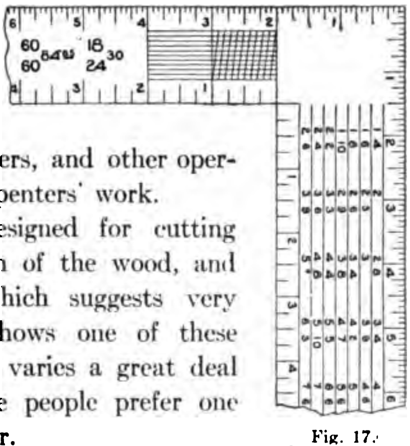


Fig. 17.
Steel Square

The distinguishing feature is the shape and arrangement of the teeth, which are shown in detail in Fig. 19. There are always a certain number of teeth to the inch length of the saw.

In this kind of a saw, the number is usually four or five, and it will be noticed that one side of the tooth is vertical while the other slopes. The vertical side of the tooth is always toward the front or point of the saw, while the sloping side is always toward the handle. The amount of slope to be given to the teeth of a saw is a matter of opinion and can be regulated when the saw is sharpened, or "filed," but the slope should always be a flat one in this kind of a saw, that is, it should make an angle of less than forty-five degrees with the horizontal, or with the line of the back of the saw.

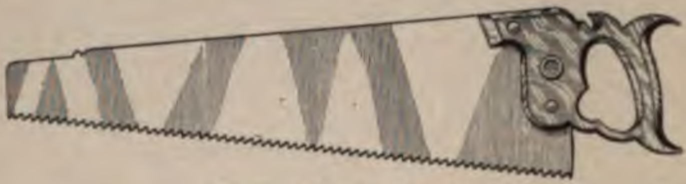


Fig. 18. Side View of Rip Saw

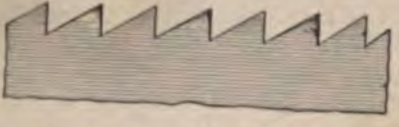


Fig. 19. Slope of Teeth in Rip Saw

It is held by some that the teeth of a rip saw should be straight on the front edge, that is, that they should have the edge at right angles with the side of the blade, while others maintain that the edge of the tooth should be cut across obliquely, so as to be at an angle of about eighty-five degrees with the side of the blade. A saw may be filed either way, according to the opinion of the owner, the determining factor being usually the kind of wood to be cut and whether the grain is absolutely straight or more or less crooked. In the latter case the edges of the teeth should certainly have a slight bevel so as to give a cutting edge. The bevel should, however, be on alternate sides of adjacent teeth, that is, one tooth should be beveled toward the right and the next toward the left and so on. This arrangement helps to keep the saw straight while cutting, and prevents it from being forced over to one side or the other. Fig. 20 shows a view of the cutting edge of a rip saw, showing the way in which the teeth should be filed.

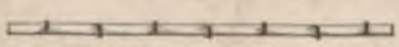


Fig. 20. Blade of Rip Saw Edge-On

Cross-Cut Saw. As has been already explained above, and as is clearly indicated by its name, this saw is intended for the cutting of wood across the grain at right angles to the direction of the fibers. It differs from the rip saw principally in the size and arrangement of the teeth, those of the cross-cut saw being smaller, usually numbering about eight to the inch. The shape of the teeth in the two kinds of saws is also different, as the front of the tooth in the cross-cut saw, instead of being straight as in the rip saw, is inclined backward at an angle of about 115 degrees, while the back of the tooth slopes at an angle of about 125 degrees. The slope of the teeth should be varied according to the hardness of the wood to be sawed, those given above being suitable for soft wood. The bevel on the front of the tooth should also be varied according to the hardness of the wood, so as to give a more or less sharp cutting edge. In the saw described above this bevel should be about sixty degrees, while for harder wood it should be as much as seventy-five degrees. In general, the harder the wood to be cut, the smaller should be the teeth of the saw. Fig. 21 shows a cross-cut saw with the slope of the teeth indicated, and Fig. 22 shows how the teeth should be filed. The cross-cut saw is also known as the "panel saw."

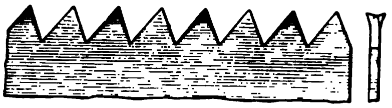


Fig. 21. Slope of Teeth of Cross-Cut Saw

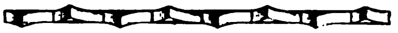


Fig. 22. Cross-Cut Saw, Blade Edge-On

Hand Saw. There is a saw, which is much used for general work, which combines the qualities of the rip saw and the cross-cut saw. It is called the "hand saw," and is a cross between the other two. It may be used for either cutting with the grain or against it, but in any case does not do such good work as the special saw which is intended for the particular kind of work which is at hand.

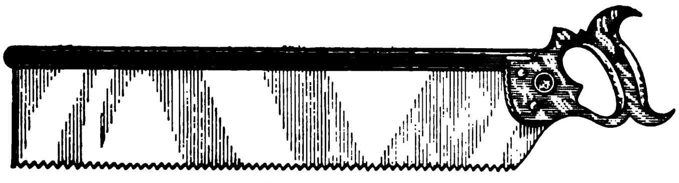


Fig. 23. Back Saw

Back Saw. Fig. 23 shows a saw which is known as a back saw, probably because of the extra piece on the back which limits the depth to which the saw will cut. It is also called a "tenon saw." There are a number of different kinds, varying in the width of the blade and in the length of the saw, and they are used for various special purposes, usually in miter boxes and for sawing bevels on moldings. Fig. 24 shows the arrangement of the teeth on a back saw. It will be seen that the front of the tooth is nearly straight, and that the slope of the back is very sharp, making the number of teeth to the inch more than in the rip or cross-cut saws.

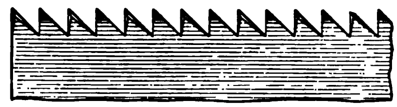


Fig. 24. Slope of Teeth of Back Saw

Keyhole Saw. Fig. 25 shows a set of saw blades which are intended to be fastened in turn to the same handle and used for various purposes. These blades are very thin and can be used for cutting out small holes such as keyholes, and it is for this reason that such saws are called "keyhole saws." The teeth are in general similar to those of the back saw, but are usually smaller.

Great care must be exercised in the filing of a saw, to give it the proper "set" to enable it to do the work required of it, and this work is better left to an expert. Most carpenters, however, like to know how to file their own saws and to keep them in good condition. A great deal has been written on this subject both in books and in trade papers, but it is almost impossible to describe, in writing, the proper methods. It is a part of the carpenter's trade which must be learned by experiment and by watching the older workmen.

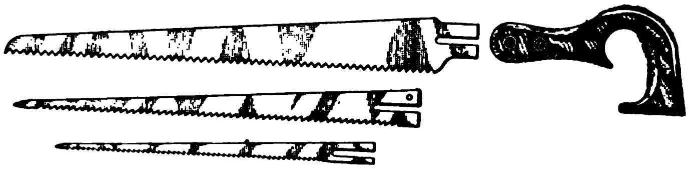


Fig. 25. Keyhole Saw with Detachable Blades

Planes. Timber comes from the mills rough from the saw, and before it can be used for any finished work it must be prepared to receive paint or other kinds of finish. This preparation consists in a smoothing or planing which can be carried to any extent, including sandpapering or even polishing. The instruments used for the rougher part of this work are called planes, after which, if more smoothing is required, come scrapers and sandpaper. There are a great many different kinds of planes, but the principle of all of them is the same. They consist of a sharp blade, or knife, in the form of a chisel, which is held in a large block of wood or iron by means of clamps, so that the knife can be kept steady and guided easily. The knife projects at the bottom of the back through a slot, and takes off a shaving which is larger or smaller according to the projection of the knife. For smoothing, the cutting edge of the knife must be absolutely straight and must be clamped into the block in such a way that the projection will be exactly the same all along the edge. Any imperfections in the edge of the knife will be repeated on the surface of the wood. Planes are in general of two kinds, namely, "jack planes" and "trying planes."

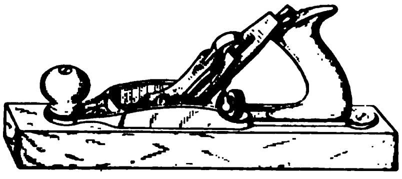


Fig. 26. Jack Plane

Jack Planes. The jack plane is used for the rougher work to give the preliminary smoothing after the lumber comes from the mill. It is bigger and, as a rule, heavier than the finishing planes, and is almost always made of wood, while the others are often made of iron. Fig. 26 shows a view of a jack plane. The handle is necessary to push the block forward, and it is usually necessary to bear down heavily on the forward end of the block to keep the knife down into the wood.

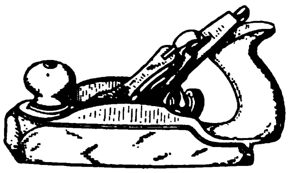


Fig. 27. Wood-Bottom Smooth Plane with Handle

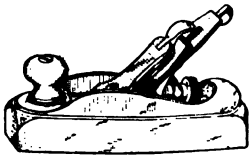


Fig. 28. Wood-Bottom Smooth Plane without Handle

Trying and Smoothing Planes. The smoothing plane is usually much smaller than the jack plane, as it is not expected to take off so much material and there does not have to be so much leverage. In construction it is similar to the jack plane, and may be made of either wood or iron. Very often, however, it is without a handle, as no great force is required to operate it. The trying plane is longer than the jack plane and is used after it so as to obtain a truer surface on the piece of timber than is possible with the jack plane. It is also used for edging boards, and it is narrower than either the jack plane or the smoothing plane. Figs. 27 and 28 show two wood-bottom smooth planes, one with a handle and one without, and Fig. 29 shows a smooth plane with an iron bottom.

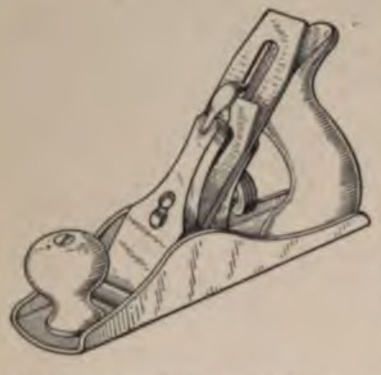


Fig. 29. Iron-Bottom Smooth Plane

In Fig. 30 is shown a sectional view of both a wood and an iron smooth plane, with the various pieces numbered, and in Fig. 31 are shown some of these same pieces separately with the same numbers attached to each. The names of the various parts are as follows:

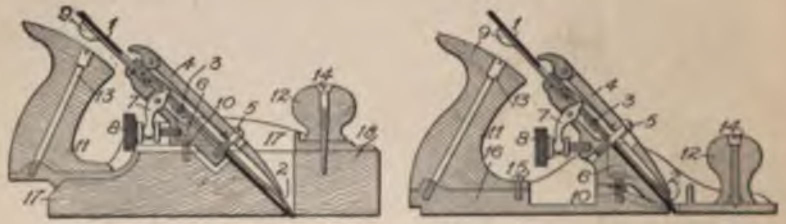


Fig. 30. Sections of Wood-Bottom and Iron-Bottom Smooth Planes

No. 1 is the "plane iron," and should be made of steel, well tempered and ground. It should be throughout of the same thickness.

No. 2 is the "plane iron cap," also of steel, the purpose of which is to protect the plane iron.

No. 3 is the "plane iron screw," which fastens the plane iron cap to the plane iron.

No. 4 is the "cap" (or "cap iron"), which holds the plane iron in place, and it is fastened to the "frog" by means of the "cap screw," No. 5.

No. 6 is the "frog," which acts as a support for the plane irons, and which is fastened to the body of the plane by the "frog screw," No. 10.

No. 7 is the "Y" adjustment, the end of which fits into an opening in the plane iron cap, and makes possible the close adjustment of the position of the plane iron. The adjustment is made by means of the brass "adjusting nut," No. 8.

No. 9 is the "lateral adjustment," by means of which the plane iron can be shifted very slightly sideways in the plane, if necessary, so as to bring it parallel with the edge of the bottom of the plane, where it passes through the slot.

No. 11 is the "handle," which is fastened to the bottom of the plane by the "handle screw," No. 15, and by the "handle bolt and nut," No. 13.

No. 12 is the "knob," fastened to the bottom by the "knob bolt and nut," No. 14.

No. 16 is the "bottom" of the iron plane, while No. 18 is the "bottom" of the wood plane.

No. 17 is called the "top casting" and occurs only on the wood bottom plane

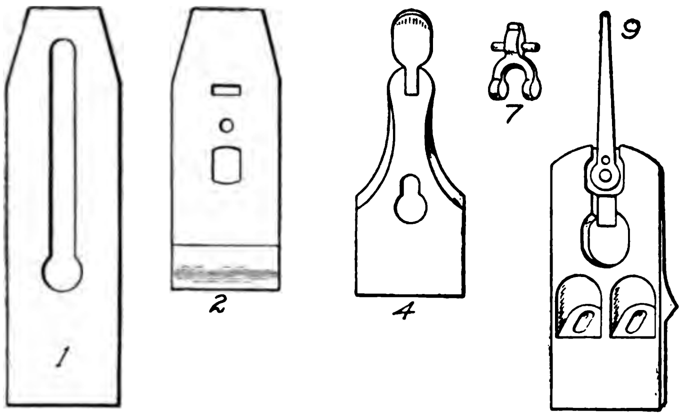


Fig. 31. Details of Parts of Smooth Plane

Nails. In general, nails are of two kinds, namely, cut nails and wire nails, the difference between the two kinds being in the material and the method of manufacture.

Cut Nails. The cut nails, also called plate nails, are stamped out of a flat iron plate, in alternate, slightly wedge-shaped pieces, and the head is afterward formed on the large end of each piece. The cut nails are made in three classes, according to finish, and are called, respectively, "common," "casing," and "finish" nails. The nails known as "finishing nails," however, are far too rough for fine finished work. The length of the nail is regulated according to the "penny," which formerly had reference to the weight, but which now is purely arbitrary. Thus a three penny nail is 1¼ inches long; four penny, 1½ inches; five penny, 1¾ inches; six penny, 2 inches; seven penny, 2¼ inches; eight penny, 2½ inches; nine penny, 2¾ inches; ten penny, 3 inches; twelve penny, 3¼ inches; sixteen penny, 3½ inches; twenty penny, 4 inches; thirty penny, 4½ inches; forty penny, 5 inches; fifty penny, 5½ inches; and sixty penny, 6 inches. The specifications which have just been given for cut nails also hold good for wire nails.

Wire Nails. Wire nails are rapidly replacing the cut nails in general use. They are now very nearly the same price and are very much stronger, so that they do not buckle up when driven into hard wood, and they are not nearly so liable to split the wood on account of their cylinder-shaped shaft, which is the same size throughout its entire length. They are made from wire, which is cut in lengths by machinery and pointed and headed. They can also be ribbed or barbed, if desired, which gives them a stronger hold on the wood. They are made with various kinds of heads, some being large and flat, so that the nail can be easily withdrawn, while others are very slightly larger than the shaft of the nail and can be made almost invisible in the finished work.

For framing, large nails should be used, from 4 to 6 inches in length. For the rougher exterior and interior finish, such as sheathing and rough flooring, nails about 3 inches long are suitable, while for the finer inside finish smaller nails from 2½ inches down to 1½ inches should be used. Roofing should be put on with special galvanized or copper nails so as not to rust out.

Screws. Screws are now used in building work to a much greater extent than was formerly the custom, largely on account of their decreased cost. They have the advantage over nails, as they do not split the wood, and they can be easily withdrawn when desired, without injuring the work materially. There are a great many different kinds of wood screws, which vary as to the shape of the head, the size of the shaft, and the length. They are made in about the same lengths as those given above for nails, and with both round and flat heads.

Screws can be had in iron, steel, copper, bronze, and brass. They are also made with the heads silver- and gold-plated, or lacquered to match finishing hardware.

LAYING OUT

Having now considered the material and the most important of the tools with which the carpenter performs his work, we shall pass to a consideration of the work itself, and see how a building of wood construction is put together.

Ground Location. In undertaking the construction of any building, the first thing to do is to make a thoughtful examination of the piece of ground upon which the structure is to be placed. This is very important as the character of the soil upon which a dwelling is located will very largely determine its sanitary condition, and will influence to a great extent the health of the occupants. Very often a difference of a few yards in the location of a building will be enough to cause the difference between a perfectly dry cellar and one which is constantly flooded with water. Water is, indeed, the one thing above all others which must be guarded against, since it is impossible to keep it out of a cellar which is sunk in damp ground, unless some elaborate system of waterproofing is employed.

Ground Water. Below the surface of the earth there is always to be found what is known as "ground water." This stands practically always at a level, and is not met with so near the surface on a slight knoll or other elevation as in a depression. If possible, a house should be located on comparatively high land, so that the floor of the cellar does not come below the ground-water level. Below the surface of a hill, however, there may be a stratum of rock which will hold the rain water and prevent it from sinking at once to the ground-water level. Such a ledge of rock causes the water to collect and then flow off in small subterranean streams, which will penetrate the walls of a cellar if they happen to be in their path.

A good way to discover the depth of the ground-water level or the existence of rock ledges beneath the surface of the ground, is to dig a number of small, deep holes at various points of the site. These should be carried below the proposed level of the cellar bottom. A suitable location for the building may thus be chosen.

If, however, it is not easy to make so thorough an examination of the site as this would allow, another method may be employed. This consists in the use of an instrument called an "auger," which is very much like an ordinary carpenter's auger or bit, though much larger. The auger generally used is about 2 inches in diameter. It is driven into the ground, and as it descends into the hole which it bores it brings to the surface small portions of all the different kinds of material through which it passes. This material may be preserved and examined at leisure. The character of the site may be determined in this way.

Staking Out. When the approximate position of the structure has been decided upon, the next step is to "stake it out," that is, the position of the corners of the building must be located and marked in some way, so that when the excavation is begun the workmen may know what are the exact boundaries of the cellar. This "staking out" should always be carefully attended to, no matter how small the building may be. In works of importance it is best to have the work done by an engineer, but on small work it is customary for the contractor or the architect to attend to it. It is well to have at hand some instrument with which angles can be accurately measured, such as a transit; but the work can be done very satisfactorily with a tape measure and a "mason's square." This simple instrument is composed of three sticks of timber nailed together as shown in Fig. 32, to form a right-angled triangle. It is important that the tape used should be accurate, a steel tape being always preferable, and that the mason's square should give an exact right angle. A mistake in the staking out may cause endless trouble when the erection of the building itself is begun, and it is then too late to remedy it.

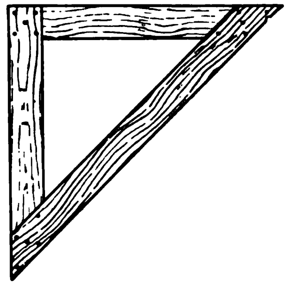


Fig. 32. Mason's Square

There are several different lines which must be located at some time during the construction, and they may as well be settled at the start. These are: The line of excavation, which is outside of all; the face of the basement wall, inside of the excavation line; and in the case of masonry building, the ashlar line, which indicates the outside of the brick or stone walls. In the case of a wood structure only the two outside lines need be located, and often only the line of the excavation is determined at the outset.

The first thing to do is to lay out upon the ground the main rectangle of the building, after which the secondary rectangles, which indicate the position of ells, bay windows, etc., may be located. Starting at any point on the lot where it is desired to place one corner of the building, a stake should be driven into the ground and lines laid out parallel and perpendicular to the street upon which the structure is to face. At the ends of these lines, which form sides of our rectangle, the lengths of which are determined by the dimensions of the building, other stakes should be driven, which define the direction and the length of the building. The exact location of the ends of the line may be indicated by a nail driven into the top of each stake.

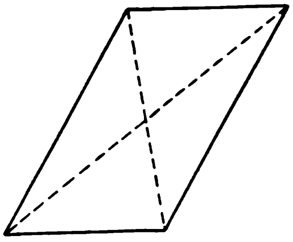


Fig. 33. Diagram Showing Wrong Ground Layout

After these lines have been thus laid out, others may be laid out perpendicular to them at the ends, with the aid of the mason's square and the tape measure. The accuracy of the right angle may be checked by the use of the "three-four-five" rule. This rule is based upon the fact that a triangle, whose three sides are, respectively, 3, 4, and 5 feet long, is an exact right-angled triangle, the right angle

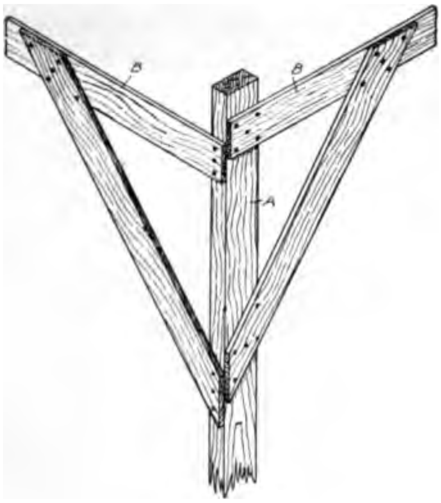


Fig. 34. Batter Board to Indicate Layout

being always the angle between the 3-foot and the 4-foot sides. This fact may be proven by applying the well-known theorem, which states that the length of the hypotenuse of a right-angled triangle is equal to the square root of the sum of the squares of the other two sides. The rule may be used as follows:

Lay off on one of the side lines already laid out on the ground any multiple of 3 feet, as 9 feet or 12 feet. On the other line, presumably at right angles to the first one, lay off the same multiple of 4 feet, as 12 feet or 16 feet. Now a straight line measured between the points so obtained, should have a length equal to the same multiple of 5 feet, as 15 feet or 12 feet. If this is not found to be the case the angle laid out is not an exact right angle, and instead of a rectangle we have a parallelogram as shown in Fig. 33. This will not do at all, and the inaccuracy must be corrected. It is possible to lay out the right angle in the first place by this same method, using two flexible cords, respectively, 4 feet and 5 feet long. The end of the 4-foot cord should be fastened at the end of the side line of the building, and the end of the 5-foot cord should be fastened on this same side line, 3 feet away from the corner. When the loose ends of both cords are held together, and the cords are both drawn taut, the point where the ends meet will be a point on the side line of the building perpendicular to the first side line. It is evident that this point must be just 4 feet from the corner, and that the distance between it and the point on the other side line, 3 feet from the corner, must be 5 feet.

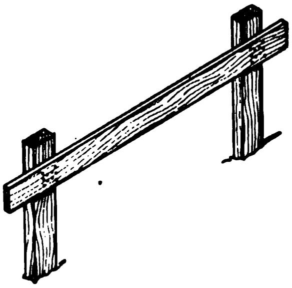
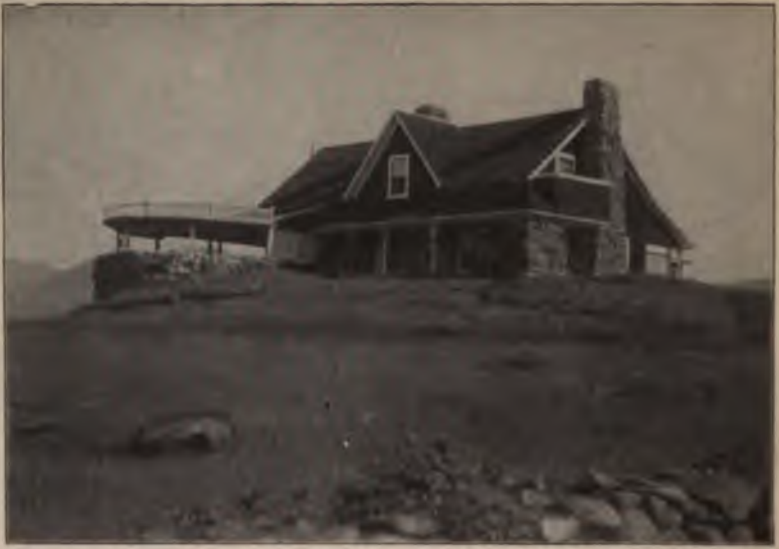


Fig. 35. Extra Strong Type of Batter Board

After all the corners of the building have been located, their position should be indicated by the use of "batter boards." One of these is shown in Fig. 34. It will be seen that it consists of a post *A*, which is set up at the corner, together with two horizontal pieces *BB*, which extend outward for a short distance along the sides of the rectangle that has been laid out. The horizontal pieces may be braced securely as shown, and the whole will be a permanent indication of the position of the corner. Notches may be cut in the top of the horizontal pieces to indicate the position of the various lines, and cords may then be stretched between the notches from batter board to batter board. These cords will give the exact location of the lines.

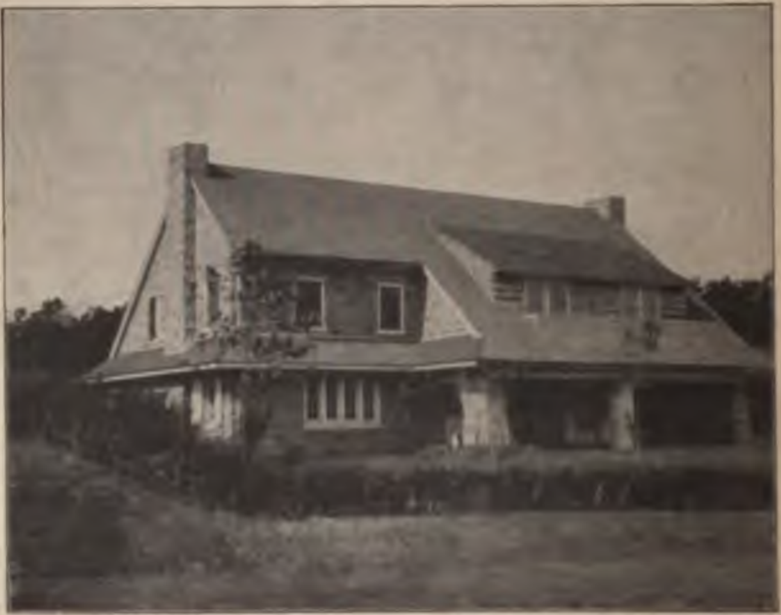
Another way to indicate the position of the lines is by driving small nails into the tops of the batter boards instead of cutting notches in them; but nails may be withdrawn, while the notches when they are once cut, can not easily be obliterated.

Batter boards should always be set up very securely, so that they will not be displaced during the building operations. If there is danger that the form of batter board shown in Fig. 34 may be displaced, because of the large size of the structure and the length of time during which they must be used, the form shown in Fig. 35 may be substituted. Two of these at right angles to each other must be placed at each corner.



HOUSE IN THE WHITE MOUNTAINS, NEW HAMPSHIRE

The Boulders, which are Plentiful in this Region, have been Used to Good Advantage.



HOUSE NEAR PHILADELPHIA, PA.

It is Verily a Part of the Landscape.

CARPENTRY

PART II

FRAMING

After the building has been laid out, and the batter boards are in place, the next work which a carpenter is called upon to do is the framing. This consists in preparing a skeleton, as we may say, upon which a more or less ornamental covering is to be placed. Just as the skeleton is the most essential part of the human body, so is the frame the most essential part of a wood building; and upon the strength of this frame depends the strength and durability of the structure. When the carpenter comes to the work, he finds everything prepared for him; the cellar has been dug and the foundation walls and the underpinning have been built. It is his business to raise the framework on them. First is the wall, then the floors, and then the roof. Therefore, the subject may be subdivided, and considered under these three main headings. In connection with the walls we may consider the partitions as well as the outside walls, and in connection with the floors we may consider the stairs, while the roof may be taken as comprising the main roof and also subordinate roofs over piazzas, balconies, and ells. This covers all the framing that will be found in a wood building, except special framing. (See page 147, Part III.) Whatever framing there is in a brick or stone building is similar to that in a wood building, with the slight differences which may be noted as we come to them.

JOINTS AND SPLICES IN CARPENTRY

Before beginning a description of the framing, it will be well to consider the methods employed in joining pieces of timber together. The number of different kinds of connections is really very small, and the principles upon which they are based may be mastered very quickly.

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All connections between pieces of timber may be classified as joints or as splices. By a "splice" we mean a connection between two pieces which extend in the same direction, as shown in Fig. 36, and each one of which is merely a continuation of the other. The only reason for the existence of such a connection is the fact that sticks of timber can be obtained only in limited lengths and must, therefore, very often be pieced. By a "joint" we mean any connection between two pieces which come together at an angle, as shown in Fig. 37, and which are, therefore, not continuous. Such a connection may be required in a great many places, and especially at the corners of a building.

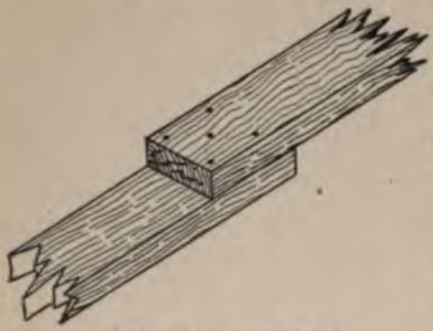
Fig. 36. Example of a Splice

Joints. The principal kinds of joints to be met with in carpentry are the "butt joint," the "mortise-and-tenon joint," the "gained joint," the "halved joint," the "tenon-and-tusk joint," and the "double-tenon joint."

Butt Joint. This is the most simple of all the joints, and is made by merely placing the two pieces together with the end of one piece against the side of the other and nailing them firmly to each other, after both have been trimmed square and true. Such a joint is shown in Fig. 38. The two pieces are perpendicular to each

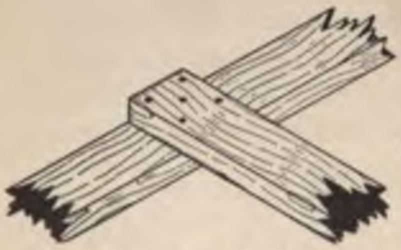
Fig. 37. Example of Plain Joint

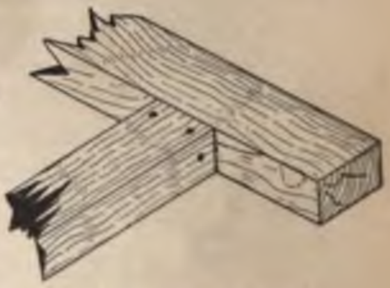
Fig. 38. Square Butt Joint

YORK
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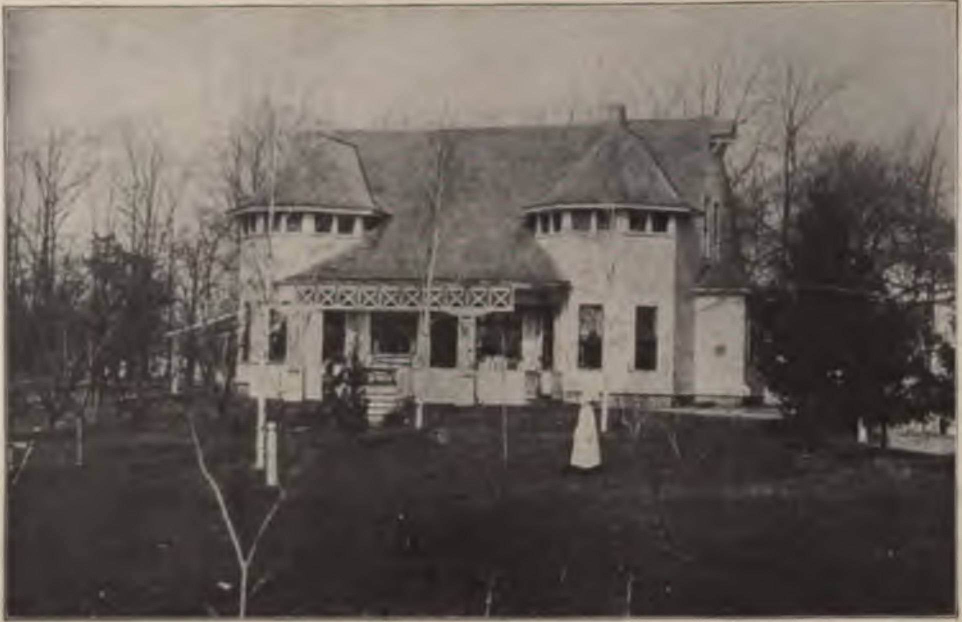
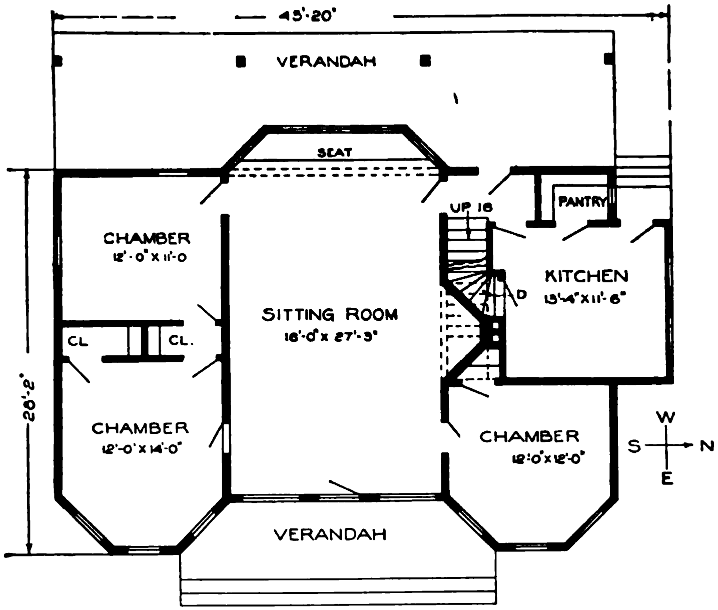


SUMMER HOME IN MICHIGAN, OF W. CARBYS ZIMMERMAN, ARCHITECT, CHICAGO, ILL.
Frame House with Brick Foundations. Built in 1904.



FIRST STORY PLAN

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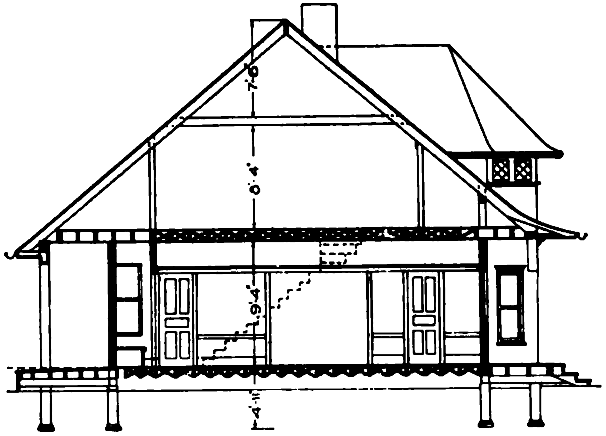
SCALE



SECTION

SUMMER HOME IN MICHIGAN, OF W. CARBYS ZIMMERMAN, ARCHITECT, CHICAGO, ILL.

House was Built in 1904, at a Time when the Prices of Material and Labor were at their Lowest. It Cost, without Heating and Plumbing, $950. Economy is Greatly Due to the Simplicity of the Roof Construction.

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ASTOR, LENOX AND
TILDEN FOUNDATIONS.

other and neither piece is cut. The nails are driven diagonally through both pieces, an operation which is known as "toe-nailing" and are driven home, if necessary, with a nail set. This is called a "square" butt joint. Fig. 39 shows two pieces which are not perpendicular to each other. They are trimmed to fit closely together, and are then nailed in place. Such a joint is called an "oblique" butt joint. The butt joint does not make a strong connection between the pieces, and should not be used if much strength is required. It depends entirely upon the nails for its strength, and these are very likely to pull out.

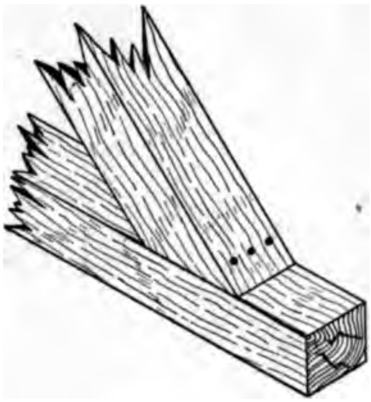

Fig. 39. Oblique Butt Joint

This form of joint is sometimes modified by cutting away a part of one of the pieces, so that the other may set down into it as shown in Fig. 40, the square joint at *A*, and the oblique joint at *B*.

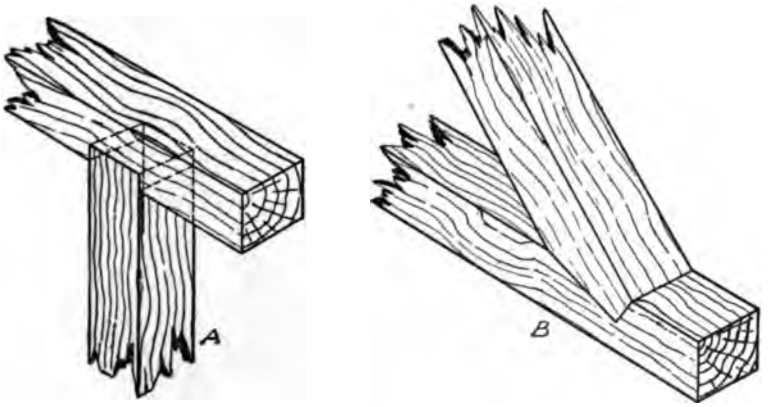

Fig. 40. Special Types of Square and Oblique Butt Joints

This gives much additional strength to the joint, especially in the case shown at *B*, where there may be a tendency for one piece to slide along the other.

Mortise-and-Tenon Joint. From the modified butt joint it is only a step to the "mortise-and-tenon" joint, which is formed by cutting a hole called a "mortise" in one of the pieces of timber, to receive a projection called a "tenon" which is cut on the end of the other piece. This arrangement is shown in Fig. 41. The mortise is shown at *A*, and the tenon is shown at *B*. It will be noticed that there is a hole bored through the tenon at *C*, and that another hole is bored in the mortised piece at *D*. These holes are so placed that when the pieces are joined together, a wood pin may be driven through both holes, thus preventing the tenon from being withdrawn from the mortise. The pin should always be inserted in a mortise-and-tenon joint. Ordinarily this pin is of hard wood, even when the pieces to be joined together are themselves of soft wood, and it may be of any desired size. Round pins from ¾ inch to ⅞ inch in diameter are ordinarily employed, although it may sometimes be found better to use a square pin.

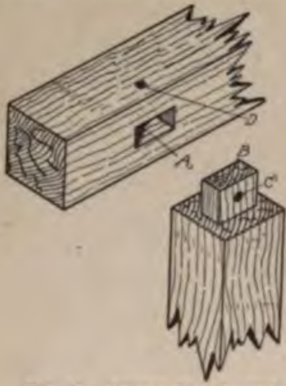

Fig. 41. Square Mortise-and-Tenon Joint

The form of mortise-and-tenon joint described above may be used wherever the pieces are perpendicular to each other. When, however, the pieces are inclined to each other, a modification of the

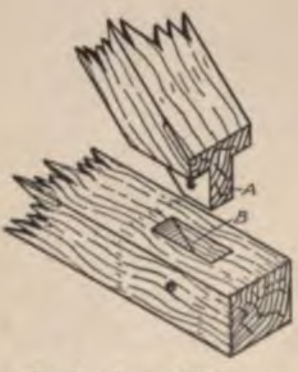

Fig. 42. Form of Bridge or Straddle Joint

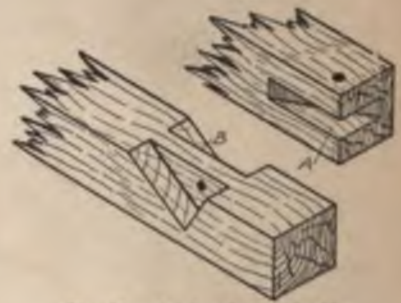

Fig. 43. Another Form of Bridge or Straddle Joint

above joint known as the "bridge" or "straddle" joint is employed. This joint is shown in Figs. 42 and 43. It is similar to the square mortise-and-tenon joint, having a similar mortise and tenon, but these are cut in a slightly different way. In Fig. 42 the tenon *A* is cut in the end of the inclined piece and fits into the mortise *B* cut in the other piece. In Fig. 43 the mortise *A* is cut in the end of the inclined piece and the tenon *B* is cut in the other piece.

Gained Joint. The joints which have so far been described are applicable only where the members are subjected to direct compression, as in the case of posts or braces, or in certain cases where direct tension is the only force acting on the pieces. When bending and shearing are to be expected, as in the case of floor beams connecting to sills or girders, a slightly different sort of joint must be employed.

One of the most common joints for such places is a modification of the mortise-and-tenon joint which is known as the "gained joint." An example of this form of connection is shown in Fig. 44, and it may be seen that the end of one piece is tenoned in a peculiar way. The tenon proper is the part *A-B-C* and this tenon sets into a corresponding mortise cut in the other piece as shown. It is evident that the tenon can not be held in place by a pin, but it may be secured by nailing.

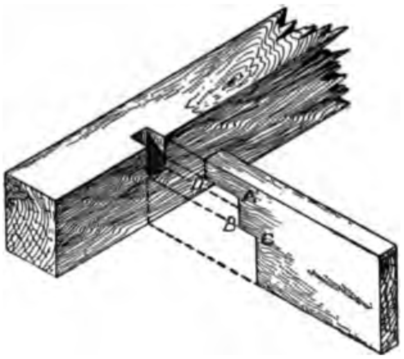

Fig. 44. Gained Joint

The reason for this peculiar form of tenon may be explained as follows: A floor beam, or any other timber, which is loaded transversely, has a tendency to fall to the ground, and must be supported at its ends either by resting directly on a wall or sill, or by being mortised into the latter member. Moreover, in order that the end of the piece resting on the support, may not be crushed or broken, a certain amount of bearing surface must be available. This same bearing surface must be provided in every case no matter whether the timber rests directly on the top of the sill or is mortised into it. Of course the simplest connection is obtained by resting the transverse piece directly on top of the sill without cutting either piece; but such a joint is not stiff and strong, and it is often necessary to bring the timbers flush with each other at the top or at the bottom. For this reason a mortised joint is used; and in order to obtain the required amount of bearing surface without cutting the piece too much, the form of tenon shown in Fig. 44 is employed. The available bearing area here is furnished by the surfaces *D-A* and *B-C* and it may easily be seen that this area is the same as would be available if the piece rested directly on top of the sill.

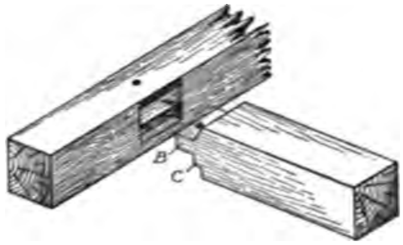

Fig. 45. Tenon-and-Tusk Joint

The operation of cutting such a tenon and mortise is known as "gaining," and one piece is said to be "gained" into the other.

Tenon-and-Tusk Joint. A joint in very common use in such situations as those which have just been mentioned is a development of the gained joint which is called the "tenon-and-tusk" or the "tusk-tenon" joint. This joint is shown in Fig. 45. The characteristic feature of this joint is to be found in the peculiar shape of the tenon which is cut in the end of one of the pieces to be joined, as shown in the figure. It may be seen that there is a small square tenon *B* cut in the extreme end of the piece, and that in addition to this there are other cuts *C* which constitute the "tusk." The bearing area is furnished partly by the under side of the tenon and partly by the under side of the tusk.

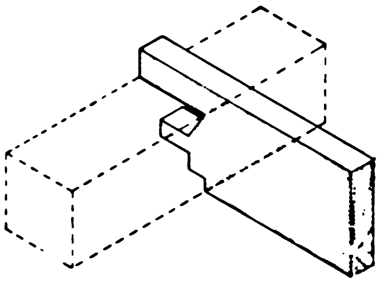

Fig. 46. Tenon-and-Tusk Joint with Specially Cut Tenon Piece

This joint makes a very good connection, and the cutting of the mortise does not weaken the piece of timber so much as does the mortise for a gained joint. It is especially applicable when it is desired to have the two pieces flush on top, although it may also be used in other positions. When the top of the tenoned piece must project above the top of the mortised piece, the tenon may be cut as shown in Fig. 46.

There are several ways of securing the tenon in place. The simplest is that shown in Fig. 47, where the pin *B* is passed through the tenon *A* and the mortised piece so as to hold the tenon securely in place. Another scheme is to cut the square tenon a little longer, as shown in Fig. 48, so as to pass clear through the mortised piece, and to fasten it with a peg *B* on the other side. The peg may be cut slightly tapering, as shown, so that when it is driven in place it will draw the pieces together. Still another plan is shown in Fig. 49. Here a small hole is cut in the header some distance back from the tenon and a nut *C* is placed in it, while a bolt *B* is passed through a hole bored lengthwise in the header to receive it. The bolt passes through the nut, which may be screwed up tight, thus drawing the pieces closely together and making the joint secure. In tightening this up, it is the bolt which must be turned, while the nut is held stationary inside of the square hole in which it is inserted and which is just large enough to receive the nut and a wrench.

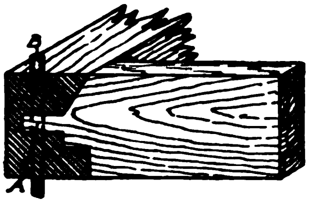

Fig. 47. Pinned Tenon-and-Tusk Joint

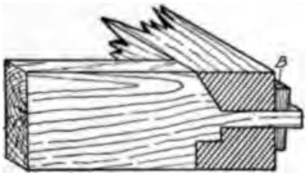

Fig. 48. Pegged Tenon-and-Tusk Joint

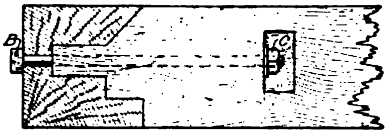

Fig. 49. Bolted Tenon-and-Tusk Joint

Double Tenon Joint. Fig. 50 shows a form of tenon joint called the "double tenon" joint, which is not very extensively used at the present time but which has some advantages. As may be readily seen, there are two small tenons *A* and *B* through which a pin may be passed if desired.

Halved Joint. A form of joint which may be used to connect two pieces which meet at a corner of a building, is shown in Fig. 51.

This is known as the "halved" joint from the fact that both pieces are cut half way through and then placed together. The pieces are held in place by nails or spikes.

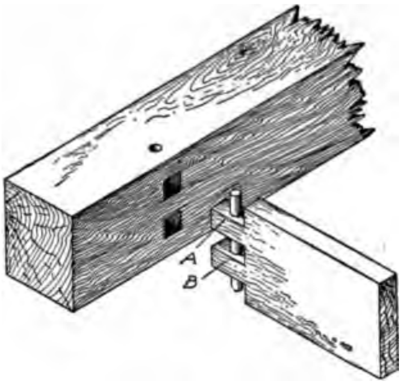

Fig. 50. Double Tenon Joint

If one piece meets the other near the center instead of at the end of the piece, and if there is danger that the two pieces may pull away from each other, a form of joint called the "dovetail" halved joint is used. This is shown in Fig. 52. Both the tenon and the mortise are cut in the shape of a fan, or dovetail, which prevents the two pieces from being pulled apart. This joint may also be cut as shown in Fig. 53, with the flare on only one side of the tenon, the other side being straight.

Splices. As already explained, a splice is merely a joint between two pieces of timber which extend in the same direction, and is sometimes necessary because one long piece can not be conveniently or cheaply obtained. The only object in view, then, is to fasten the two pieces of timber together in such a way that the finished piece will be in all respects equivalent to a single unbroken piece, and will satisfy all of the requirements of the unbroken piece. This is really the only measure of the efficiency of a splice.

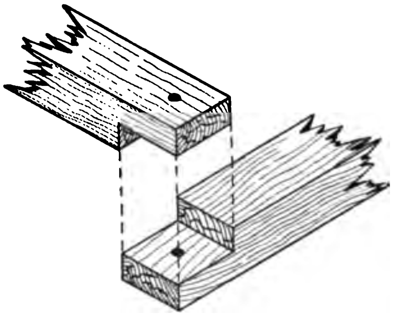

Fig. 51. Halved Joint

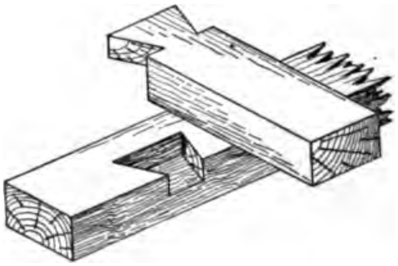

Fig. 52. Dovetail Halved Joint

There are three kinds of forces to which a piece may be subjected, namely: Compression, tension, and bending. A splice which would be very effective in a timber acted upon by one of these forces might be absolutely worthless in a piece which must resist one of the other forces. We have, therefore, three classes of splices, each designed to resist one of these three forces.

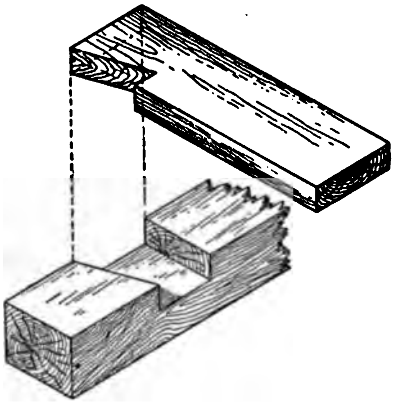

Fig. 53. Dovetail Halved Joint with One Flare

Splices for Compression. The simplest splices are those intended to resist compression alone, and of these the most simple is that shown in Fig. 54. This piece is said to be "fished"; the two parts are merely sawed off square and the ends placed together. A couple of short pieces *A-A*, called "fish plates," are nailed on opposite sides to keep the parts in line. In the splice shown in Fig. 54, the splicing pieces are of wood, and ordinary nails are used to fasten them in place, but in more important work thin iron plates are used, the thickness being varied to suit the conditions. They are held in place by means of bolts with washers and nuts.

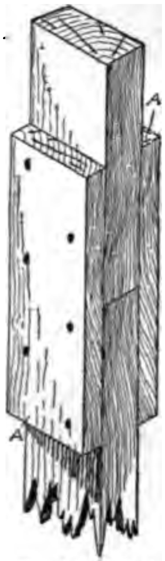

Fig. 54. Fished Splice

If for any reason it is desired not to use plates of this kind, four small pieces called dowels may be used, as indicated in Fig. 55. These dowels may be set into the sides of the timbers to be spliced, so that they do not project at all beyond the faces of these pieces and a very neat job may thus be obtained.

It is but a step to pass from this simple splice to the "halved" splice shown in Fig. 56. It will be noticed that it is much like the halved joint described above, the only difference being that the pieces are continuous, instead of being perpendicular to each other. The nature of the splice will be easily understood from the figure without further explanation. A modification of this which is somewhat more effective, is shown in Fig. 57. The cuts are here made on a bevel in such a way that the parts fit accurately when placed together, and the splice is called a "beveled" splice.

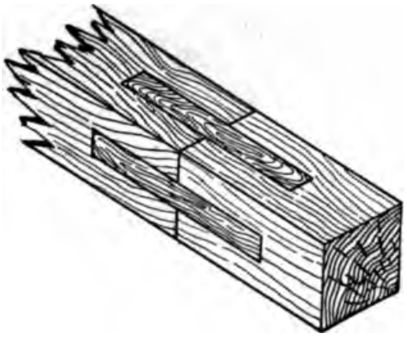
Fig. 55. Doweled Splice

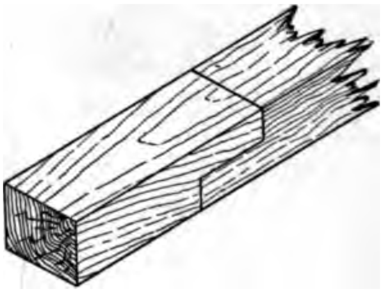
Fig. 56. Halved Splice

The halved splice is perhaps the best that can be used to resist direct compression, and when it is combined with fish plates and bolts, as shown in Fig. 58, it may be used in cases where some tension is to be expected. It will be noticed that in Fig. 58 the ends of the timbers are cut with a small additional tongue *A*, but this does not materially strengthen the splice and it adds considerably to the labor of forming it. In general it may be said that the simplest splice is the most effective.

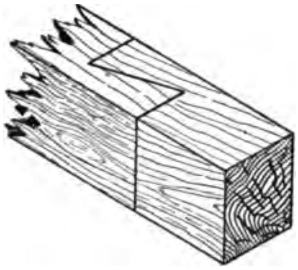
Fig. 57. Beveled Splice

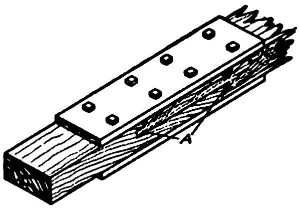

Fig. 58. Halved Splice with Fish Plates and Bolts

Whenever the pieces are cut to fit into one another, as they do in the halved and beveled splices, the splice is known as a "scarf" splice, and the operation of cutting and joining the parts is called "scarfing." Scarf splices are used, as we have already seen, both alone and in combination with fish plates. The fished splice is always the stronger, but the splice where scarfing alone is resorted to has the neatest appearance.

Splices for Tension. There are several common forms of splices for resisting direct tension. These differ from each other mainly in the amount of labor involved in making them. The simplest of them is shown in Fig. 59, and it will be seen that it is only a slight modification of the halved splice used for resisting compression. It is evident that the pieces can not pull apart in the direction of their length until the timber crushes along the face marked *A-B*, or shears along the dotted line *A-C*. By varying the dimensions of the splice it may be made suitable for any situation. The parts are held closely together by the light fish plate shown in the figure, which also incidentally adds something to the strength of the splice.

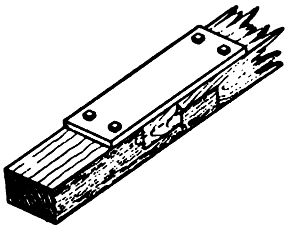

Fig. 59. Squared Splice for Tension

Instead of cutting the ends of the beams square, as shown in Fig. 59, they frequently are cut on a bevel as shown in Fig. 60, and a further modification may be introduced by inserting a small "key" of hard wood between for the pieces to pull against, Fig. 61. This key is usually made of oak and may be in two parts, as shown in

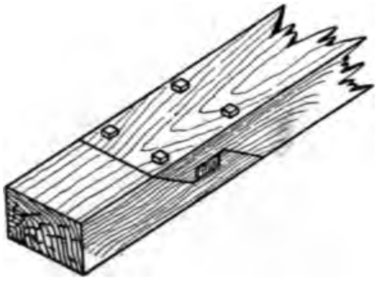

Fig. 60. Beveled Splice for Tension

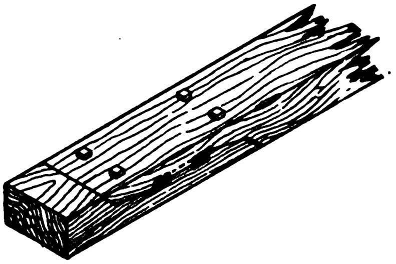

Fig. 61. Beveled and Keyed Splice for Tension

Fig. 62, each part in the shape of a wedge, so that when they are driven into place a tight joint may be obtained. The two wedge-shaped pieces may be driven in from opposite sides, the hole being a little smaller than the key. If the key is made much too large for the hole, however, a so-called "initial" stress is brought into the timbers, which uses up some of their strength even before any load is applied. This should be avoided.

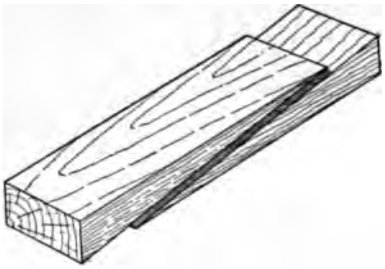
Fig. 62. Key for Beveled and Keyed Joint

If it is desired, two or more keys may be employed in a splice, the only limiting condition being that they must be placed far enough apart so the wood will not shear out along the dotted line shown in Fig. 61. Another feature of the splice here shown is the way in which the pieces are cut with two bevels on the end instead of one. One bevel starts at the edge of the key and is very gradual, the other starts at the extreme end of the piece and is rather steep and sharp. These bevels can be used only in joints which resist tension alone. If such a splice were subjected to compression, the beveled ends would slide on each other and push by each other very easily, except as they are prevented from so doing by the fish plates, if these are used.

Tension Splice with Fish Plates. The splices for tension which have so far been described have all been scarf joints, but there is a fished splice which is very commonly used for tension. This splice is shown in Fig. 63. The fish plates, in this case of wood, are cut into the two pieces to be spliced, so as to hold them firmly together. The pieces can not be pulled apart until one of the plates shears off along the dotted line *A-B*. The distance *C-D* must also be made large enough so that the piece will not shear. This splice is very often used for the lower chords of the various forms of wood trusses, and it is considered one of the best that has been devised for resisting direct tension.

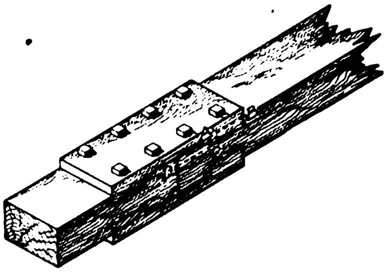
Fig. 63. Tension Splice with Fish Plates

Splices for Bending. It sometimes happens that a piece which is subjected to a bending stress must be spliced, and in this case the splice must be formed to suit the existing conditions. It is well known that in a timber which is resisting a bending stress the upper part of the piece is in compression, and the tendency is for the fibers to crush, while the lower part of the piece is in tension, and the tendency is for the fibers to pull apart. To provide for this, a form of splice must be selected which combines the features of the tension and compression splices. Fig. 64 shows such a splice. The parts are scarfed together, as is the case with other splices described, but in this case the end of the top piece is cut off square to offer the greatest possible resistance to crushing, while the underneath piece is beveled on the end as there is no tendency for the timbers to crush.

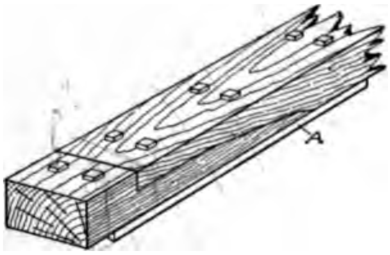

Fig. 64. Splice Designed for Bending Strains

We have already seen that in the lower part of the splice, there is a tendency for the parts to be pulled away from each other. In order to prevent this, a fish plate, *A*, is used, which must be heavy enough to take care of all the tension, since it is evident that the wood can not take any of this. The plate must be securely bolted to both parts of the splice. There is no need of a fish plate on the top of the pieces because there is no tendency for the pieces to pull apart on top, and the bolts shown in the figure are sufficient to prevent them from being displaced.

In any case where it is not desirable to scarf the pieces in a splice subjected to bending, the form of butt joint shown in Fig. 65 may be used. The plates, either of wood or iron, are in this case bolted to the sides of the pieces. If wood is used, of course the plates must be made very much heavier than if iron is used. In either case they must be large enough to take care of all the bending stress, and a sufficient number of bolts must be used to fasten them securely to both parts of the splice.

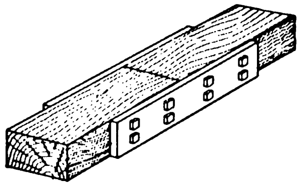

Fig. 65. Butt Joint with Plates

JOINTS AND SPLICES IN JOINERY

We have considered a few of the most important joints and splices used in the putting together of rough framing, and we will now take up some of the methods used in the joining together of finished work, where more care is necessary and where the joint or splice must very often be concealed from view. Much ingenuity has been exercised in devising some of these concealed joints, and great credit is due to the workmen, unfortunately unknown, who first invented them.

Splices. *Plain Butt Splice.* Fig. 66 shows the simplest kind of splice which can be used, similar in principle and construction to the butt joint already described. Here the pieces are simply planed off square and true on the ends and glued together with nothing but the glue to hold them. It is evidently not a very strong splice and should not be used where any tension or bending is likely to come at the point where the splice is made.

Splice with Spline. Fig. 67 shows a splice which is a slight advance over the simple butt splice. It is formed by ploughing the ends of the pieces to be spliced after they have been finished square and true, and inserting into the slot thus formed a third piece, which is called a "spline" or a "tongue." The spline is about 1 inch or less in width, and about $\frac{1}{8}$ or $\frac{3}{16}$ inch thick. Its length is regulated by the width of the pieces to be spliced together. As will be explained later, this form of connection is made use of in the construction of the better class of doors.

Tongued-and-Grooved Splice. This form of splice is somewhat similar to the splice with splines, the difference being that only one of the pieces is ploughed, and the other is rabbeted on both sides so as to leave a projecting portion called a "tongue" which fits into the groove formed by ploughing the other piece and is fastened there securely with glue. The tongue should be about $\frac{3}{8}$ inch thick, and should project about the same distance from the main body of the piece. The groove in the other piece must, of course, be of corresponding dimensions. The figures given are for $1\frac{1}{8}$-inch stuff, which is the most common thickness of lumber used in cabinet work and interior finishing. For other thicknesses they should, of course, be varied. The tongued-and-grooved splice, Fig. 68, is used extensively in flooring.

Rabbeted Splice. In Fig. 69 is shown what is known as a "rabbeted splice." It is similar to the halved splice described before but depends upon glue or small nails for its strength. It must be much more carefully made than the rough halved splice. As will be seen each piece is rabbeted on one side so that when put together they fit into each other perfectly. The tongue should here be about one half of the thickness of the piece and its projection from the main body of the piece should be about equal to its thickness. If this tongue is made too thin and projects too much, it is liable to curl up, as the wood shrinks in drying, and make ugly ridges on the finished work besides leaving the splice open.

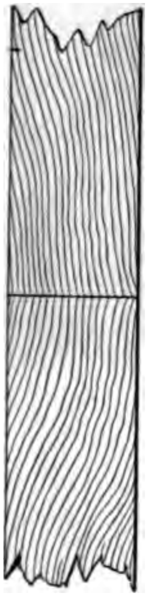
Fig. 66. Plane Butt Splice

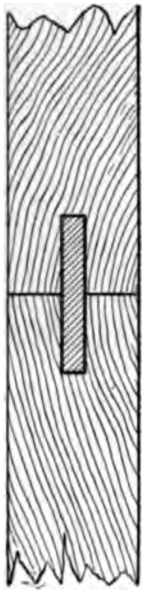
Fig. 67. Splice with Spline

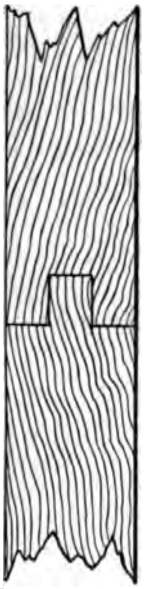
Fig. 68. Tongued-and-Grooved Splice

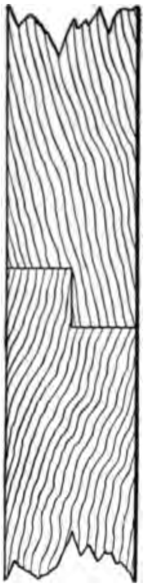
Fig. 69. Rabbeted Splice

Filleted Splice. A form of splice which is little used in this country, but which can occasionally be worked to advantage, is the filleted splice which is shown in Fig. 70. It is made by rabbeting the two pieces to be spliced, as in the case of the rabbeted splice, but this time both on the same side, and a third piece called a "fillet," which is somewhat like the spline in the splice with a spline, is inserted in the hollow space so as to join them together. This prevents any possibility of an open joint. The fillet is generally made somewhat less than one half the thickness of the pieces to be spliced, and is about 1 inch in width.

Battened Splice. A variation of the filleted splice, which is quite generally made use of where great strength is not required and it is only necessary to cover up the butt splice neatly, is what is called a "battened splice," Fig. 71. As will be seen this consists simply in covering the butt splice with a small piece called a "batten." The batten should be about the same size as that given above for the size of the fillet, but can be made large or small as desired.

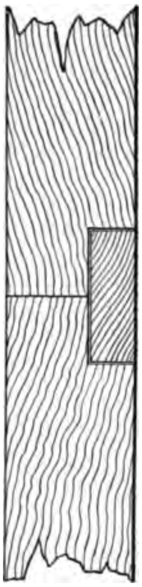

Fig. 70. Filleted Splice

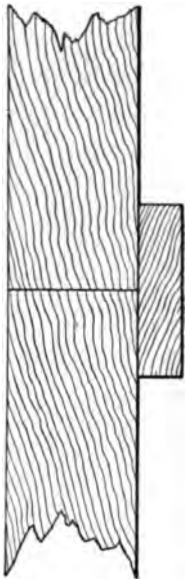

Fig. 71. Battened Splice

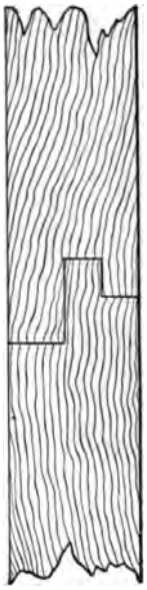

Fig. 72. Tongued-Grooved-and-Rabbeted Splice

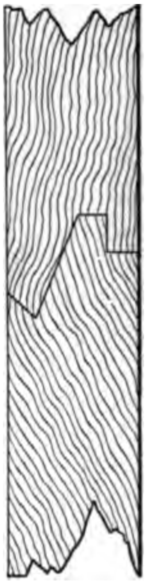

Fig. 73. Tongued-Grooved-and-Splayed Splice

Tongued-Grooved-and-Rabbeted Splice. A combination splice, which combines the advantages of the tongued-and-grooved and the rabbeted splices, is shown in Fig. 72. The groove is ploughed in the end of one piece and the tongue is left projecting on the end of the other piece while, in addition to this, one of the pieces is rabbeted against the other. The tongue should be about $\frac{3}{8}$ inch thick and should project about the same amount from the end of the piece. One piece of the splice should be rabbeted against the other a distance of about $\frac{3}{8}$ inch. This splice is considerably stronger than the simple tongued-and-grooved splice, but it is a great deal harder to make and is more expensive as regards both material and labor.

Tongued-Grooved-and-Splayed Splice. Another variation of the tongued-and-grooved splice consists in the introduction of a splay on one side of the tongue and a corresponding splay on one side of the groove so that they fit into each other. Fig. 73 shows this arrangement. It makes a very neat form of splice and it looks well, but it is apt to be less strong than the simple tongued-and-grooved splice and much weaker than the tongued-grooved-and-rabbeted splice, though stronger than the simple rabbet. This is, of course, a very troublesome and expensive form of splice to make, and it is, in consequence, seldom used.

Joints. *Miters.* A miter is a joint between two pieces which come together at a corner at an angle of ninety degrees with each other. Strictly such a joint can be called a mitered joint only when each piece is beveled off so that each will come to a sharp edge at the corner. There are, however, a number of different methods of cutting the pieces so that they will come together in this way.

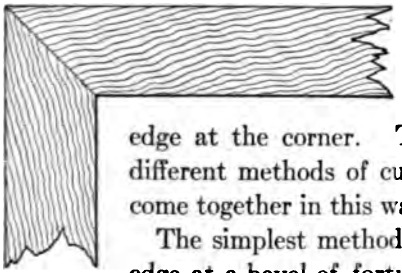

Fig. 74. Miter Joint

The simplest method is to cut off each piece along the edge at a bevel of forty-five degrees, so that when they are put together they will make an angle of ninety degrees with each other. This method is shown in Fig. 74. In practice, however, it is very difficult to make a perfect joint of this kind. The joint is very apt to open on the outside of the corner and leave an unsightly crack there, and great care must be exercised to see that the bevels are cut to exactly forty-five degrees, as the least variation will cause endless trouble.

Miter with Spline. A simple mitered joint may be made stronger by the introduction of a spline, which is inserted at the joint in a direction perpendicular to it. This is shown in Fig. 75. The spline used in this way is also known as a "feather." It strengthens the joint very considerably, and a joint of this kind is a great improvement over the simple mitered joint. The spline or feather should be about ¾ inch wide and about ⅜ inch thick. Its length, of course, varies with the width of the pieces which meet at the joint. Great care must be taken in ploughing out the grooves into which the spline fits, for if they are not exactly the same distance from the corner on each of the pieces the finished joint will not be neat and true.

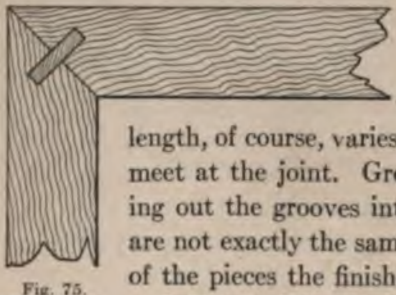
Fig. 75. Miter with Spline

Rabbeted Miter Joint. There are two or three variations of the simple mitered joint made by rabbeting one piece on the other at the corner, so that the miter goes only part way through each piece. One of these joints is shown in Fig. 76, in which only one of the pieces is rabbeted and the other piece has a simple miter. This form of joint can only be used when one piece is somewhat wider than the other, so that it can be rabbeted a little and still have a miter which will match the miter on the narrower piece. If both pieces are of the same width, this can not be done. Wherever it is possible, however, this joint is an excellent one to use.

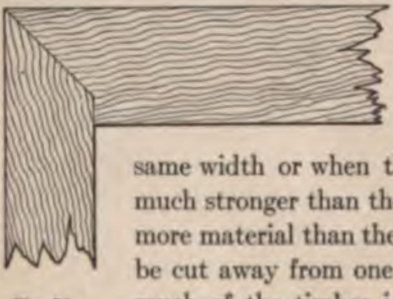
Fig. 76. Rabbeted Miter Joint

Fig. 77 shows another way of rabbeting a mitered joint which is much better than the method shown in Fig. 76. This can be done when both pieces are of the same width or when they are of different widths. It is much stronger than the other method but requires a little more material than the simple mitered joint, as some must be cut away from one piece to form the rabbet and thus much of the timber is wasted. Very often, however, it happens that this timber would have to be used in any case and, when this occurs, the waste need not be considered. The increased strength of the joint would seem to be worth much more than the small additional amount of material which is required.

Rabbeted-Mitered-and-Splined Joint. In Fig. 78 is shown a joint which is mitered and at the same time rabbeted and splined. In order

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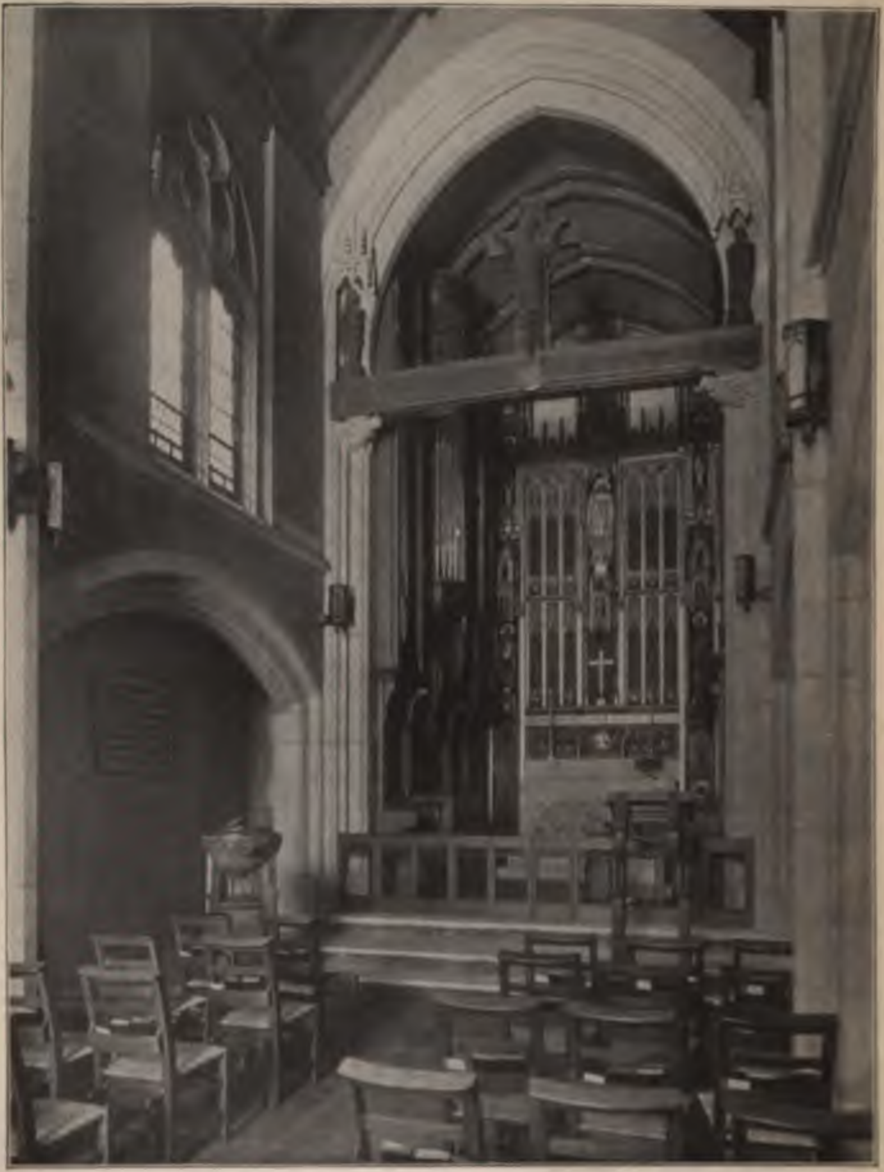
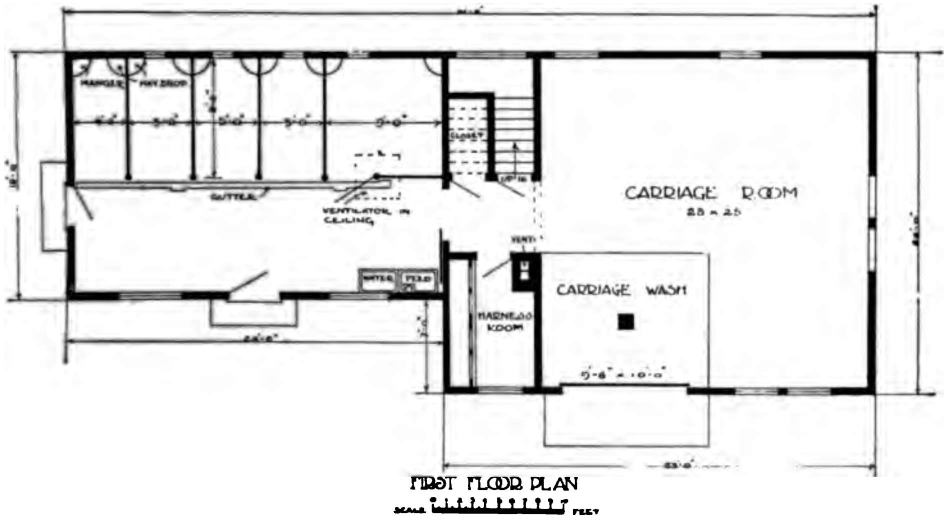


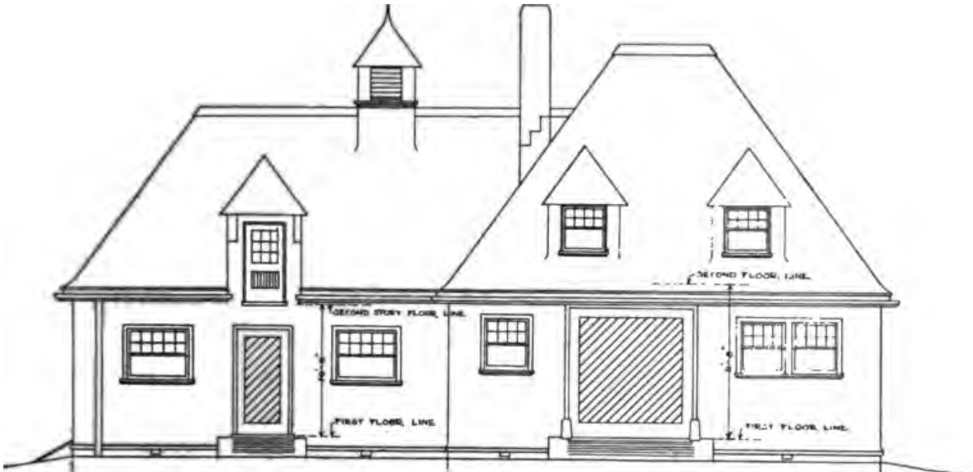
GRACE MEMORIAL CHAPEL, CHICAGO, ILL.

Cram, Goodhue & Ferguson, Architects, Boston and New York.

Interior of Gray Pressed Brick; Trimmings of Terra-Cotta of Color and Finish Similar to Bedford Stone. Floor of 9-in. Welsh Quarries; Chancel Floor of Mercer Tile. For Exterior, See Vol. I, Page 10; for Detail of Wood-Carving, See Vol. II, Page 10.



FIRST FLOOR PLAN



SOUTH ELEVATION

STABLE FOR MR. J. S. HANNAH, LAKE FOREST, ILL.

Shepley, Rutan & Coolidge, Architects, Chicago, Ill.

For Location, See Vol. I, Page 74; for Exterior and Plans of House, See Vol. I, Pages 74 and 90.

to accomplish this, one piece is cut at an angle of forty-five degrees and then rabbeted to the thickness of the other piece. The other piece is then cut with a miter to natch that left on the first piece and also cut to match the rabbet. Both pieces are ploughed to take a spline, and thus a very strong joint is formed which combines the advantages of the mitered joint and the rabbeted or splined joints. The spline in this case should be about ⅜ inch thick and about 1⅛ inches wide and should, in all cases be of hard wood.

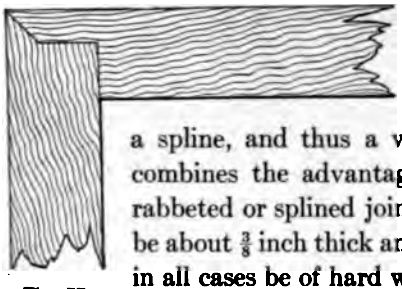


Fig. 77. Rabbeted Miter Joint

Joint Mitered and Keyed. Another way of strengthening a mitered joint is by inserting what are known as "keys" into the pieces on the outside of the joint. These keys are thin slices of hard wood which are placed in slots prepared to receive them and held in place by means of glue. As the glue fastens them securely to each of the pieces at the joint, they hold them firmly together and prevent the joint from opening. Fig. 79 shows a joint of this kind. The keys, of course, show on the outside of the joint, but they can be cut very thin and only the edge of them can be seen. The keys give a great amount of additional strength to the connection and are more effective than is a spline for preventing the joint from opening, as they come right out to the edge of both pieces and can be placed as near together as seems to be necessary. Sometimes, instead of being placed horizontally, or in a plane perpendicular to the edge of the joint, they are inclined as shown in Fig. 80. This arrangement strengthens the joint still more.

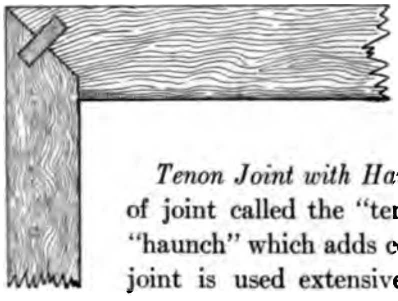


Fig. 78 Rabbeted Mitered-and-Splined Joint

Tenon Joint with Haunch. In Fig. 81 is shown a form of joint called the "tenon joint," with the addition of a "haunch" which adds considerably to its strength. This joint is used extensively in the making of doors. One of the pieces to be joined is rabbeted on each side to about one-third of its depth, leaving a projecting part called the "tenon" about one-third the thickness of the piece. This tenon is then rabbeted on either the top or the bottom, but instead of being cut entirely back to the body of the piece, the rabbet is stopped a little short of this and a "haunch" is left. In Fig. 81, *A* is the tenon and *B* is the haunch. The other of the two

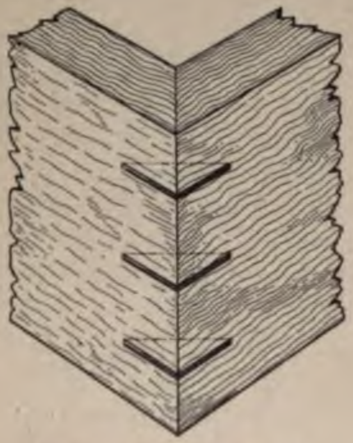


Fig. 79. Mitered Joint Keyed Square

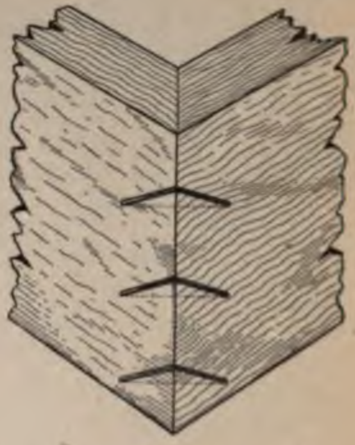


Fig. 80. Mitered Joint Keyed Diagonally

pieces which are to be joined is cut with mortises to receive the tenon and the haunch in the first piece. Fig. 81 shows the simplest form of simple tenon joint, but there are many variations of this, two of which are shown in Figs. 82 and 83. Fig. 82 shows a single tenon joint with two tenons, while Fig. 83 shows a double tenon joint which has four tenons. Both of these joints have haunches as well as tenons. The one most commonly used is that shown in Fig. 82.

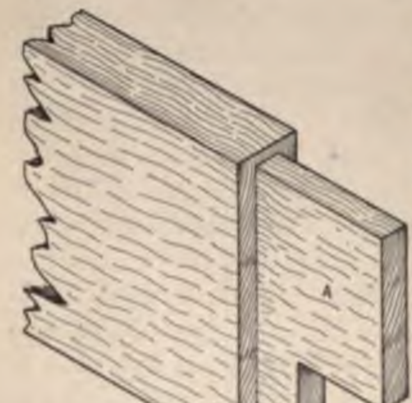


Fig. 81. Tenon Joint with Haunch

All of the splices so far considered have been end to end splices, that is, they have been those kinds which would be used in fastening pieces together at the ends. It often becomes necessary, however, to fasten pieces together side by side. Any of the methods already described for splices will be applicable in such a case, but there are in addition a few others which are especially useful, two or three of which will now be described.

Dovetail Key. This method consists in the use of a strip of wood which is applied to the back of the several pieces to be held together and prevented from slipping by means of glue. The strip, however, is let into the pieces a little way in a special manner known as dovetailing, which prevents it from pulling out, and gives it an especially strong hold on them. Fig. 84 shows this arrangement both in elevation and in section. It is useful in making up large panels from narrow boards. In this method, only one of the pieces must be glued to the strip, the others being left free to move.

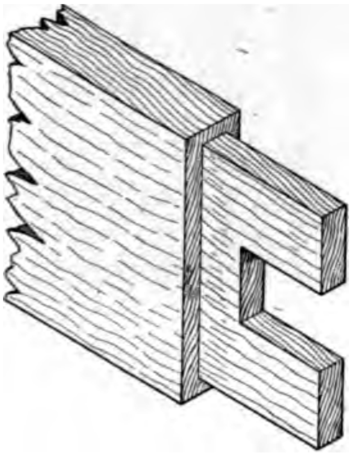


Fig. 82. Single Tenon Joint with Two Tenons

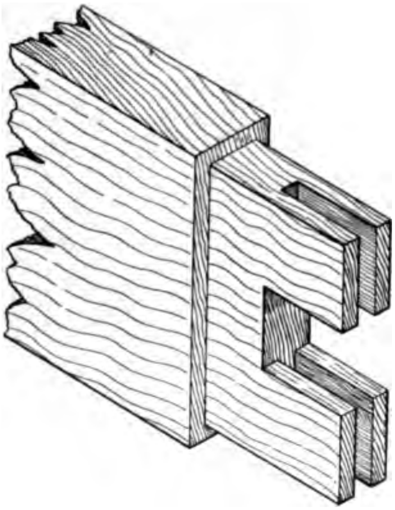


Fig. 83. Double Tenon Joint with Four Tenons

Another method of accomplishing this same result is by the use of a strip which sets against the back of the pieces to be joined, but is not let into them at all, Fig. 85. It is held in place by means of screws which go through slotted holes in the strip. This is in order that the pieces may have a chance to swell or shrink without bulging or splitting. It is usually customary to employ brass slots which are let into the wood. These resist much better the wear of the screws and prevent them from working loose. If, however, the strip is of very hard wood this is not always necessary.

A third method is that shown in Fig. 86. This is sometimes called the "button" method on account of the use of the small side pieces or buttons which fit over the center strip and hold the pieces of board together, at the same time allowing them to swell or shrink freely. Only the small pieces are screwed to the boards, the center strip being fastened to one of the pieces only. This arrangement takes up a little more room than the others and looks somewhat more clumsy but is quite satisfactory otherwise. In all three of the methods described, the strip should be from 3 to 4 inches wide.

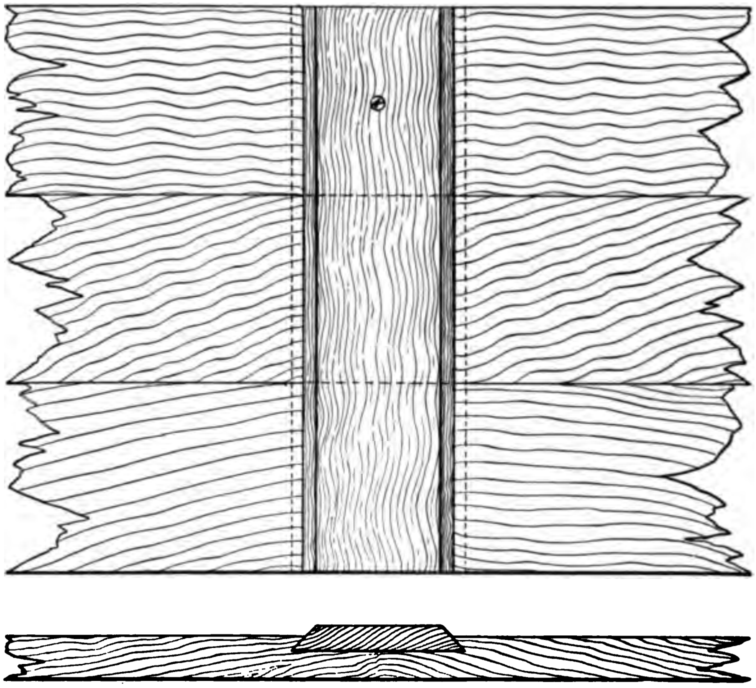


Fig. 84. Method of Binding Boards Together by Means of Dovetail Key

Dovetailing. There is another way of joining two pieces meeting at right angles, and it is better and stronger than any other but, on account of the work involved in the process of making the joint, is seldom used except in the best work. This method is known as dovetailing and there are three different ways of arranging the dovetails as will be shown. The first is the simple dovetail which is illustrated in Fig. 87. As will be seen, it consists in cutting tenons in the end of one piece and mortises in the end of the other piece, which are of such a shape as to form a sort of locking device, so that the pieces can be separated only by a pull in one particular direction. The use of glue makes the joint still stronger. Of course, the forming of a joint of this kind requires a large amount of time and considerable skill.

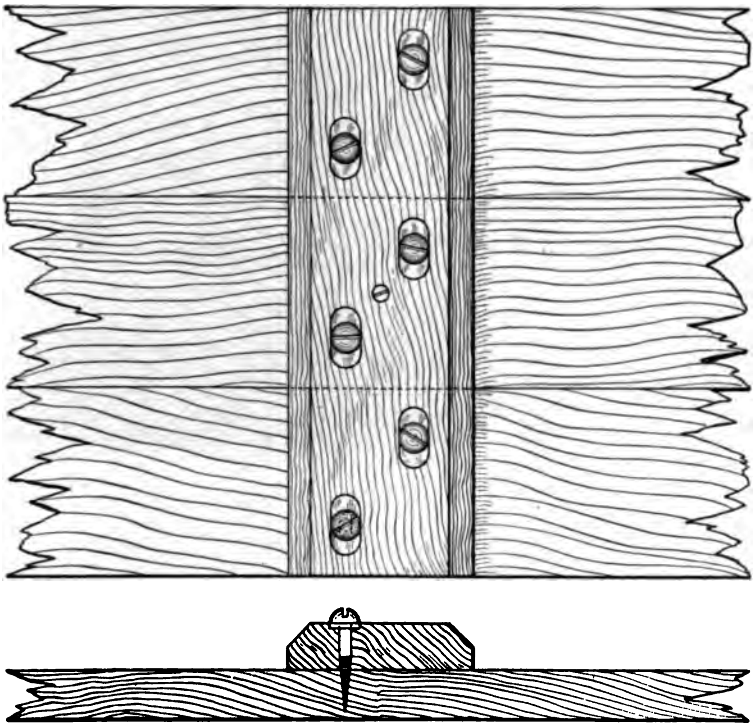


Fig. 85. Method of Binding Boards Together by Means of Strip with Slots and Screws

A variation of the simple dovetail joint which is much used in the manufacture of drawers and in any other position where it is desirable that the joint shall be concealed from one side only, is shown in Fig. 88. This is called a lap dovetail, its peculiarity consisting in the fact that in one of the pieces the mortises are not cut the full thickness, but only partly through the wood, so as to leave a covering or lap, which prevents the joint from being seen.

A further development of the dovetail joint is shown in Fig. 89. In this case the work is so arranged that the joint can not be seen from any side of the finished product. This is accomplished by cutting the same tenons and mortises as in the case of the simple dovetail joint, but not directly on the end of the pieces. They are so cut as to project at an angle of forty-five degrees, and thus to form a combination of the mitered joint and the dovetail joint with the tenons and mortises entirely out of sight when the pieces have been put together. This joint is obviously not so strong as

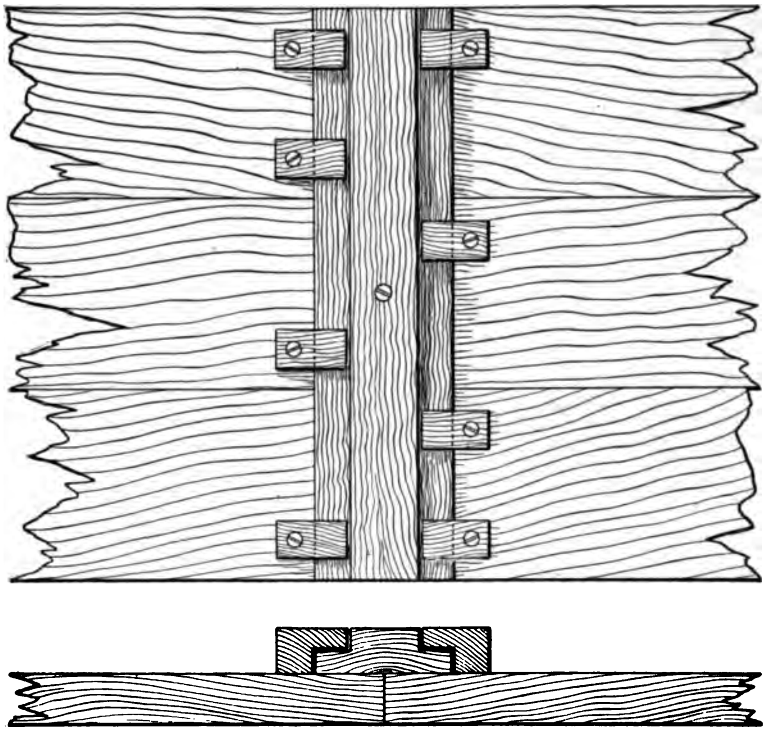


Fig. 86. Button Method of Binding Boards Together

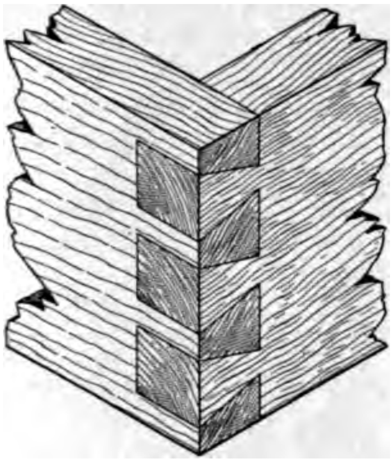


Fig. 87. Simple Dovetail

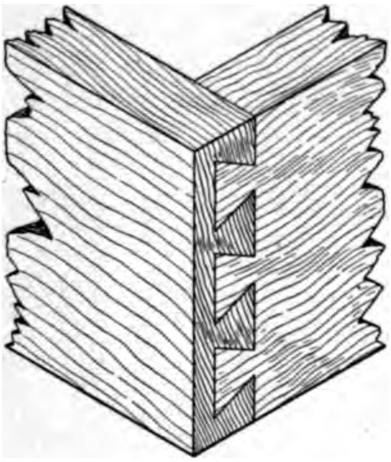


Fig. 88. Lap Dovetail

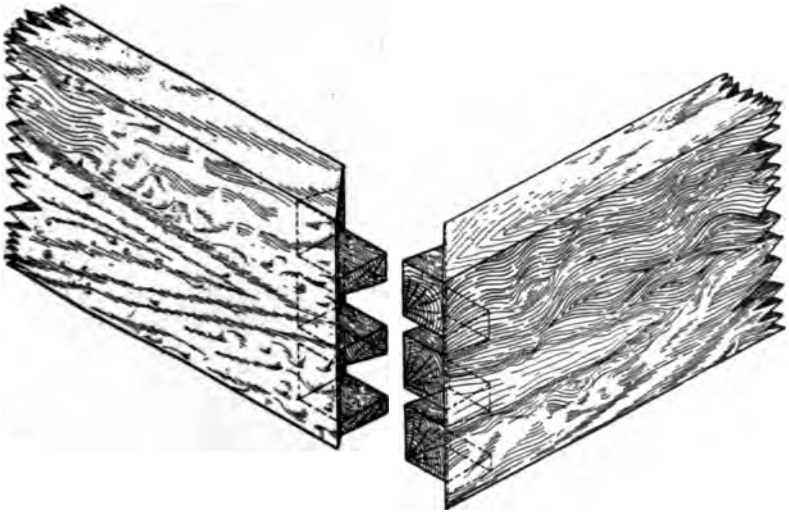


Fig. 89. Further Development of Dovetail Joint

are the other forms of dovetail joints because the tenons are not so large.

WALL

Let us next consider the framing of the walls of a wood or frame building. In this work there are two distinct methods of procedure, known, respectively, as "braced framing" and "balloon framing," of which the first is the older and the stronger method, while the second is a modern development and claims to be more logical and at the same time more economical than the other. Balloon framing has come into use only since about the year 1850, and it is still regarded with disfavor by many architects, especially by those in the eastern states. Figs. 90 and 91 show the framing of one end of a small building by each of the two methods, the braced framing in Fig. 90 and the balloon framing in Fig. 91.

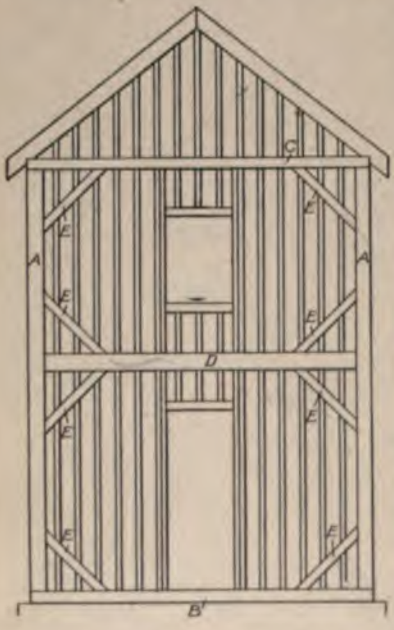


Fig. 90. Example of Braced Framing

Braced Frame. In a full-braced frame all the pieces should be fastened together with mortise-and-tenon joints, but this requirement is much modified in common practice, a so-called "combination" frame being used in which some pieces are mortised together and others are fastened by means of spikes only. A framework is constructed consisting in each wall of the two "corner posts" *AA*, Fig. 90, the "sill" *B*, and the "plate" *C*, together with a horizontal "girt" *D* at each story to support the floors, and a diagonal "brace" *E* at each corner, which, by keeping the corner square, prevents the frame from being distorted.

Balloon Frame. In a balloon frame there are no braces or girts, and the intermediate studs *FFF*, Fig. 91, are carried straight up from the sill *H* to the plate *K*, with a light horizontal piece *J*, called a "ribbon" or "ledger board," set into them at each floor level to support the floor joists. This frame depends mainly upon the boarding for its stiffness, but sometimes light diagonal braces are set into the studs at each corner to prevent distortion. The methods by which all these pieces are framed together will be explained in detail under the proper headings.

Sill. The sill is the first part of the frame to be set in place. It rests directly on the underpinning and extends all around the building, being jointed at the corners and spliced where necessary; and since it is subject to much cutting and may be called upon to span quite considerable openings (for cellar windows, etc.) in the underpinning, it must be of a good size. Usually it is made of 6 × 6-inch square timber, but in good work it should be 6 × 8 inches and nothing lighter than 6×6 inches should be used except for piazza sills. For piazza sills a 4 × 6-inch timber may be used. The material is generally spruce, although sometimes it is Norway pine or native pine (depending upon the locality).

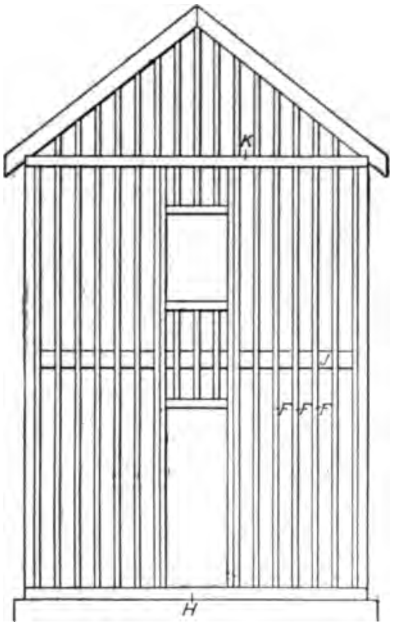


Fig. 91. Example of Balloon Framing

The sill should be placed on the wall far enough back from the outside face to allow for the water table, which is a part of the outside finish, which will be described later; and 1 inch should be regarded as the minimum distance between the outside face of the sill and the outside face of the underpinning, Fig. 92. A bed of mortar *A*, preferably of cement mortar, should be prepared on the top of the underpinning, in which the sill *C* should rest; and the under side of the sill should be painted with one or two coats of linseed oil to prevent it from absorbing moisture from the masonry. In many cases, at intervals of from 8 to 10 feet, long bolts *B* are set into the masonry. These bolts extend up through holes bored in the sill to receive them and are fastened at the top of the sill by a washer and a nut screwed down tight. They fasten the sill, and consequently the whole frame securely to the underpinning, and should always be provided in the case of light frames in exposed positions.

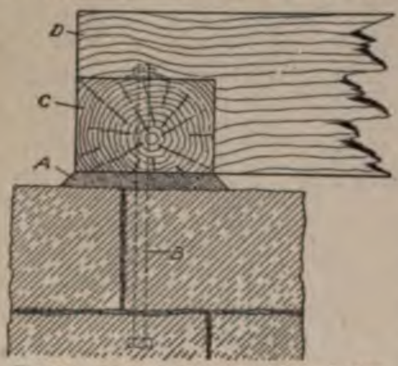


Fig. 92. Method of Setting Underpinning, Sill, and Joists

The beams or "joists" *D*, which form the framework of the first floor, are supported at one or both ends by the sill and may be fastened to it in any one of several different ways. The ideal method is to hang the joist in a patent iron hanger fastened to the sill, as shown in Fig. 93, where *A* is the sill, *B* the joist, and *C* the hanger. In this case neither the sill nor the joist need be weakened by cutting, but it is too expensive a method for ordinary work, although the saving in labor largely offsets the cost of the hanger. The usual method is to cut a mortise in the sill to receive a tenon cut in the end of the joist, as shown at *A* in Fig. 94. The mortises are cut in the inside upper corner of the sill. They are about 4 inches deep and cut 2 inches into the width of the sill and are fixed in position by the spacing of the joists.

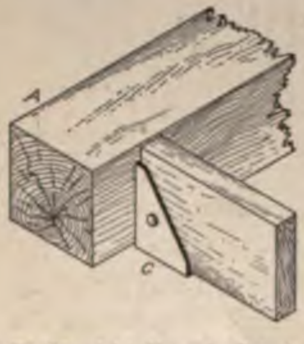


Fig. 93. Joist Hung in Patent Hanger

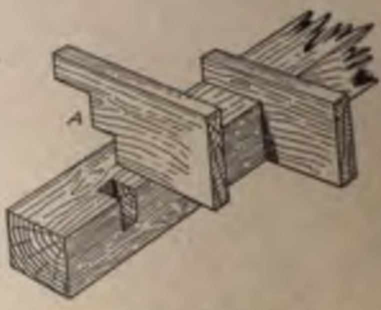
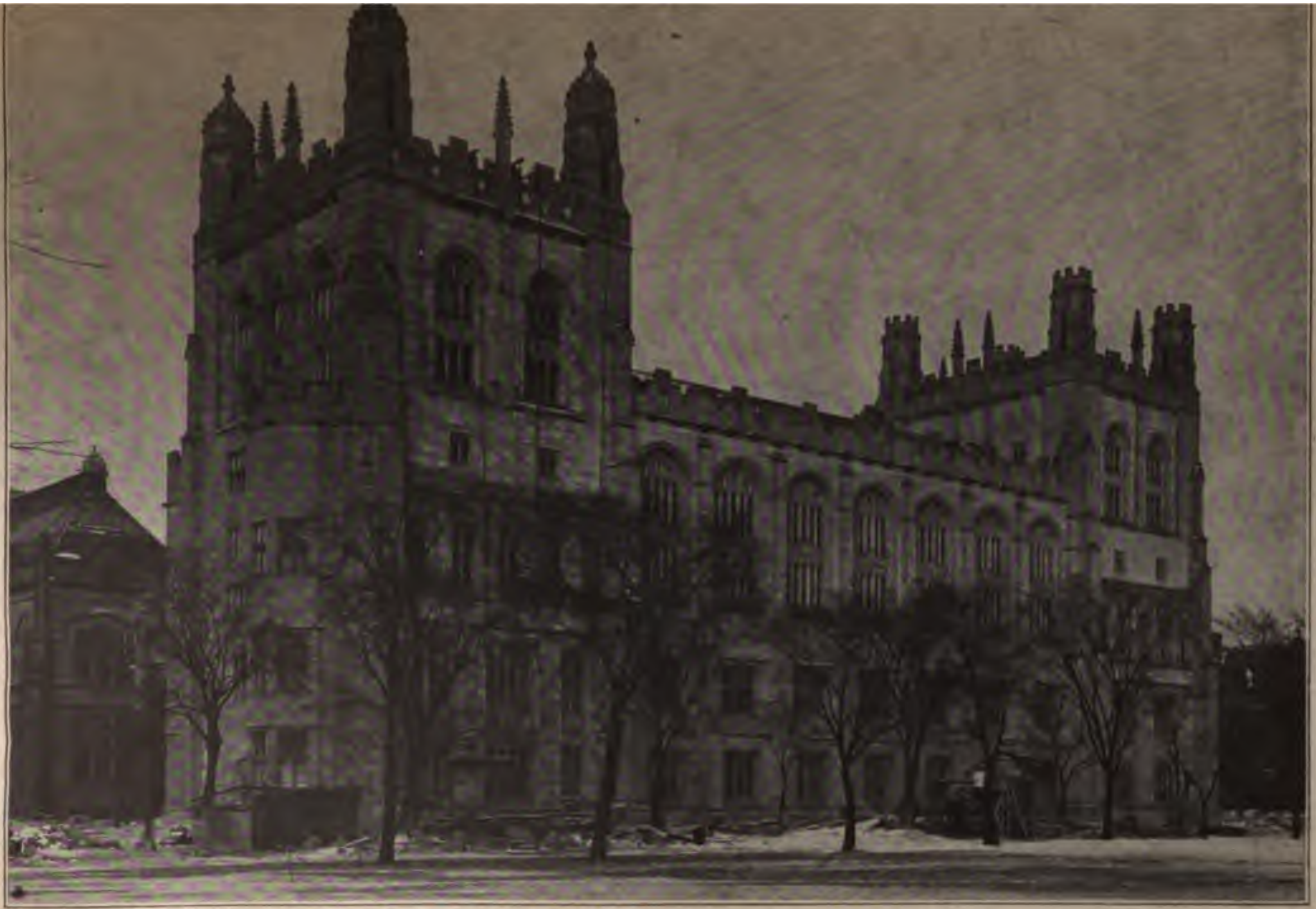


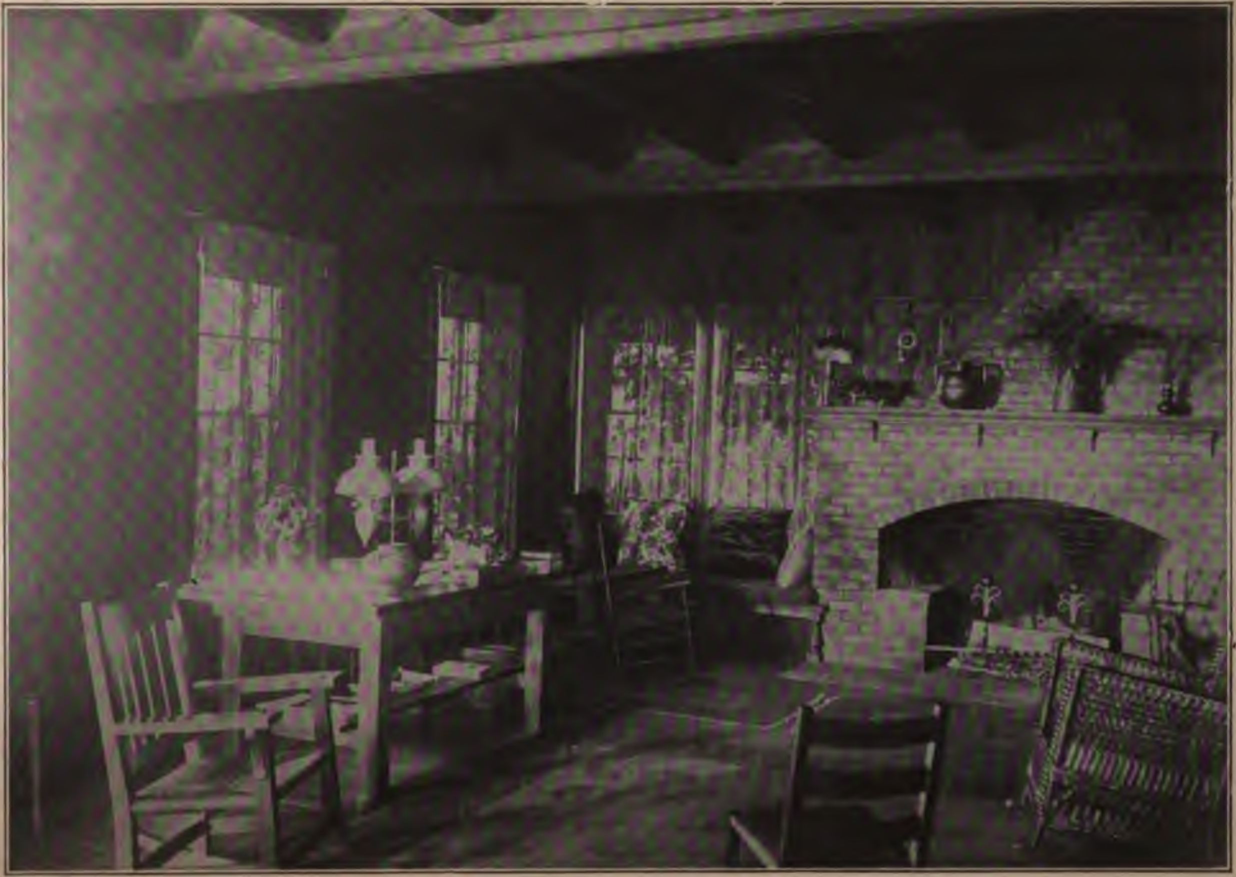
Fig. 94. Example of Sill Mortised to Receive Joist



HARPER MEMORIAL LIBRARY BUILDING AT THE UNIVERSITY OF CHICAGO

Shepley, Rutan and Coolidge, Architects, Chicago

Completed in 1912. The Building Faces South on the Midway Plaisance. Entire Exterior, Including All Traceries and Carvings, is of Bedford Stone



LIVING ROOM IN SUMMER COTTAGE FOR THE MISSES DUMMER, AT HARBOR POINT, MICH.

Pond & Pond, Architects.

Hemlock Woodwork, Walls Stained a Silver Gray, Ceilings Stained a Gray Brown.

Fireplace of Paving Brick.

Mortises are also cut in the sill to receive tenons cut in the lower ends of the studs, as shown at *B* in Fig. 95. They are cut the full thickness of the studding, about 1½ inches in the width of the sill and about 2 inches deep. The position of these mortises is fixed by the spacing of the studding, and by the condition that the outer face of the studding must be flush with the outer face of the sill in order to leave a plain surface for the boarding.

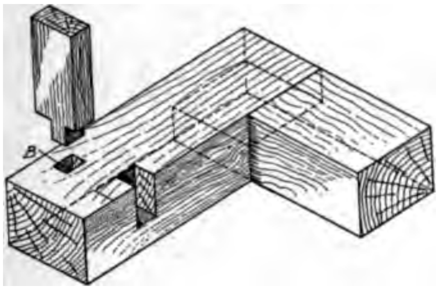


Fig. 95. Sills Mortised to Receive Studs

The sills are usually halved and pinned together at the corners, as shown in Fig. 96; but sometimes they are fastened together by means of a tenon *A* cut in one sill, which fits into a mortise cut in the other, as shown in Fig. 97. This method may be stronger than the other, but the advantage gained is not sufficient to compensate for the extra labor involved. Sills under 20 feet in length should be made in one piece, but in some cases splicing may be necessary. In such cases a scarf joint should always be used, the splice should be made strong, and the pieces should be well fitted together.

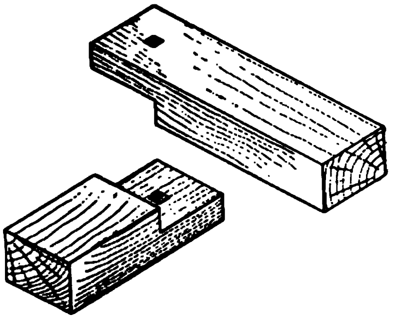


Fig. 96. Sills Halved and Pinned at Corners

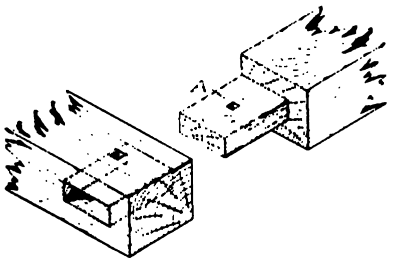


Fig. 97. Sills Sometimes Joined by Tenon Joint

In some parts of the country it is customary to "build up" the sill from a number of planks 2 or 3 inches thick, which are spiked securely together. A 6×6-inch sill can be made in this way from three planks 2 inches thick and 6 inches wide, as shown in Fig. 98. Planks of any length may be used, and may be so arranged as to break joints with each other in order that the sill may be continuous without splicing. It is often easier and cheaper to build up a sill in this way than it is to use a large, solid timber, and if the parts are well spiked together, such a sill is fully as good as the other. When a sill of this kind is used, however, it should always be placed on the wall in such a way that the planks of which it is composed will rest on their edges, and not lie flat.

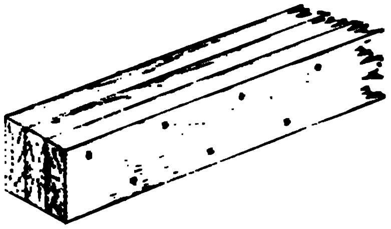
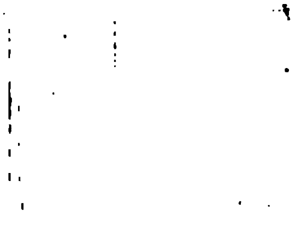


Fig. 98. Built-up Sill

Corner Posts. After the sill is in place, the first floor is usually framed and roughly covered at once, to furnish a surface on which to work, and a sheltered place in the cellar for the storage of tools and materials, after which the framing of the wall is continued. The corner posts are first set up, then the girts and the plate are framed in between them, with the braces at the corners to keep everything in place, and lastly the frame is filled in with studding. The corner posts are pieces 4 × 8 inches, or sometimes two pieces 4×4 inches placed close together. Corner posts must be long enough to reach from the sill to the plate. The post is really a part of only one of the two walls which meet at the corner, and in the other wall a "furring [illegible] is placed close up against the post so as to



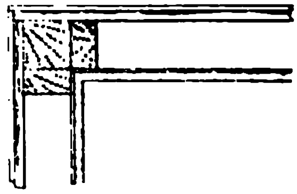


Fig. 100. Plan of Another Form of Corner Post

[illegible] and give a firm nailing for the lathing in both [illegible] shown in plan in Fig. 99. A is the corner [illegible] the plastering, and D the boarding and [illegible] sometimes a 4 × 4-inch piece is used for the corner post and a 2×4-inch furring stud is set close against it in each wall to form the solid corner, as shown in plan in Fig. 100; but a 4×4-inch stick is hardly large enough for the long corner post, and the best practice is to use a 4×8-inch piece although in very light framing a 4×6-inch piece might be used. A tenon is cut in the foot of the corner post to fit a mortise cut in the sill, and mortises *CC*, Fig. 101, are cut in the post at the proper level to receive the tenons cut in the girts. Holes must also be bored to receive the pins *DD* which fasten these members to the post.

The braces are often only nailed in place, but it is much better to cut tenons on the braces for pins, as shown at *A* in Fig. 102. The plate is usually fastened to the posts by means of spikes only, but it may be mortised to receive a tenon cut in the top of the post.

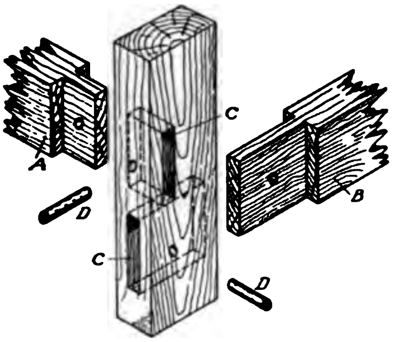


Fig. 101. Details of Tenon Joints for Corners

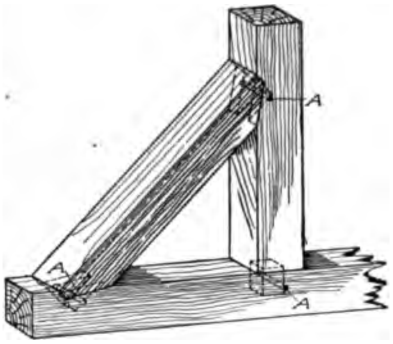


Fig. 102. Corner Bracing with Mortise-and-Tenon Joints

In the case of a balloon frame no mortises need be cut in the posts for the girts or braces, as they are omitted in this frame; but the post must be notched instead, as shown in Fig. 103, to receive the ledger board or ribbon and the light braces which are sometimes used.

Girts. The girts are always made of the same width as the posts, being flush with the face of the post both outside and inside, and the depth is usually 8 inches, although sometimes a 6-inch timber may be used. The size is, therefore, usually 4×8 inches. A tenon at each end fits into the mortise cut in the post, and the whole is secured by means of a pin *DD*, as shown in Fig. 101. The pin should always be of hard wood and about $\frac{7}{8}$ inch in diameter.

It is evident that if the girts in two adjoining walls were framed into the corner post at the same level, the tenons on the two girts would conflict with each other. For this reason the girts *A* which run parallel with the floor joists are raised above the girts *B* on which these joints rest, and are called "raised girts" to distinguish them from the others which are called "dropped girts." The floor joists are carried by the dropped girts, and the raised girts are so placed that they are just flush on top with the joists which are parallel to them.

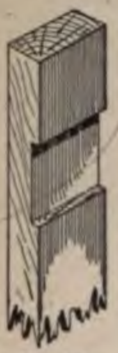


Fig. 103. Notched Post in Balloon Framing

Ledger Board. The heavy girts are used only in the braced frame. In the balloon frame, light pieces called "ledger boards" or "ribbons" are substituted for them. These are usually made about $\frac{7}{8}$ inch thick and 6 or 7 inches deep, and are notched into the posts and intermediate studs instead of being framed into them as in the braced frame. This notching is shown in Fig. 104, on which *A* is the ledger board and *B* the stud. The ledger boards themselves are not cut at all, but the floor joists which they carry are notched over them, as shown in Fig. 105, and spiked to them and to the studding. In Fig. 105, *A* is the joist, *B* the ledger board, and *C* the stud. Even in the braced frame a ledger board is usually employed to support the joists of the attic floor, which carry little or no weight. The disadvantage of the ledger board is that, as a tie between the corner

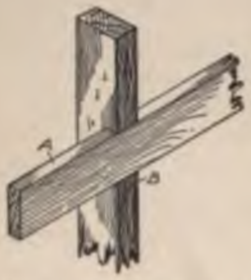


Fig. 104. Notched Stud with Ledger Board

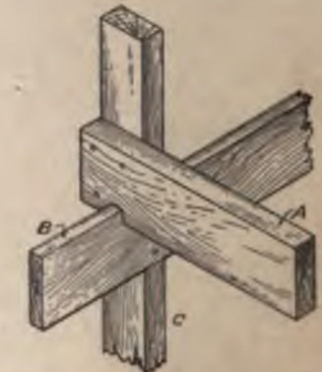


Fig. 105. Ledger Board with Notched Floor Joist in Place

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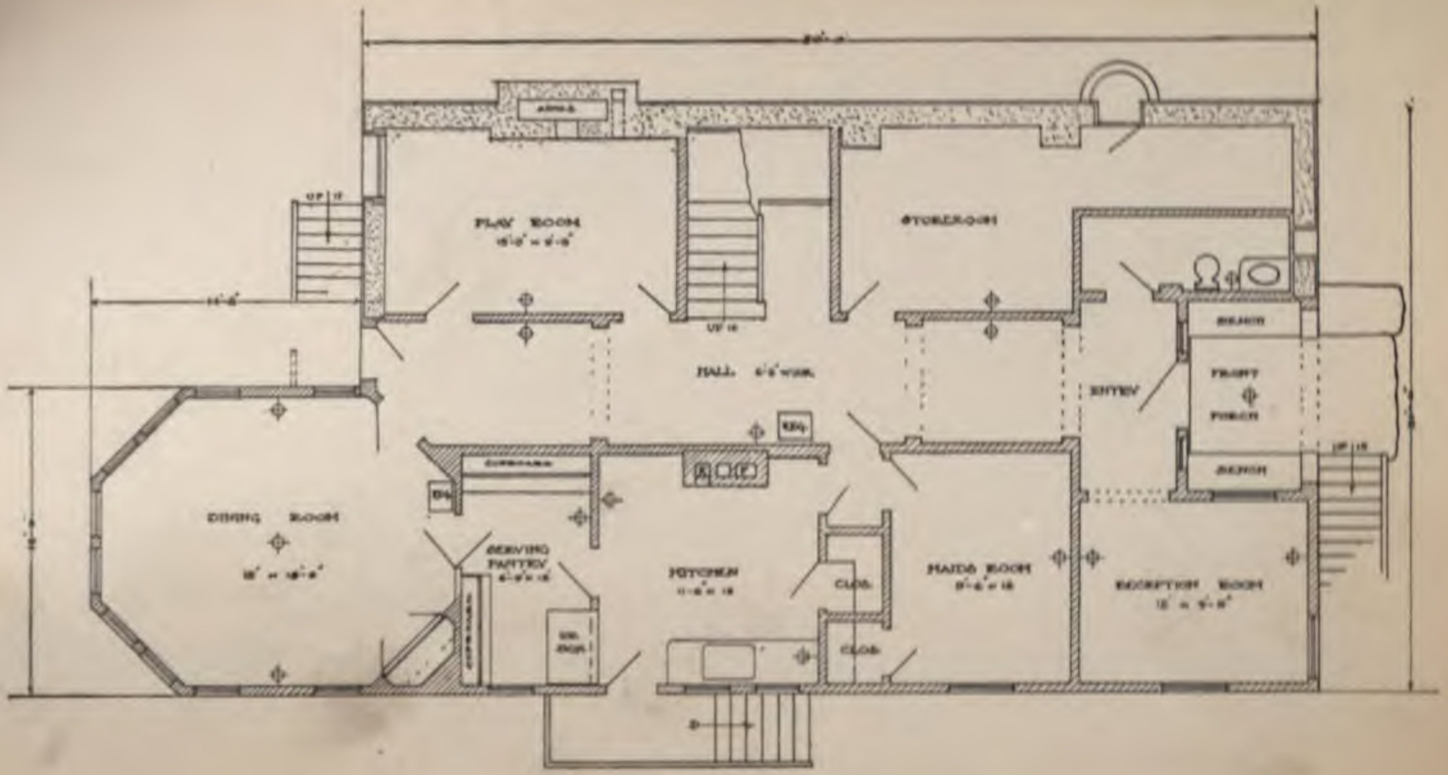
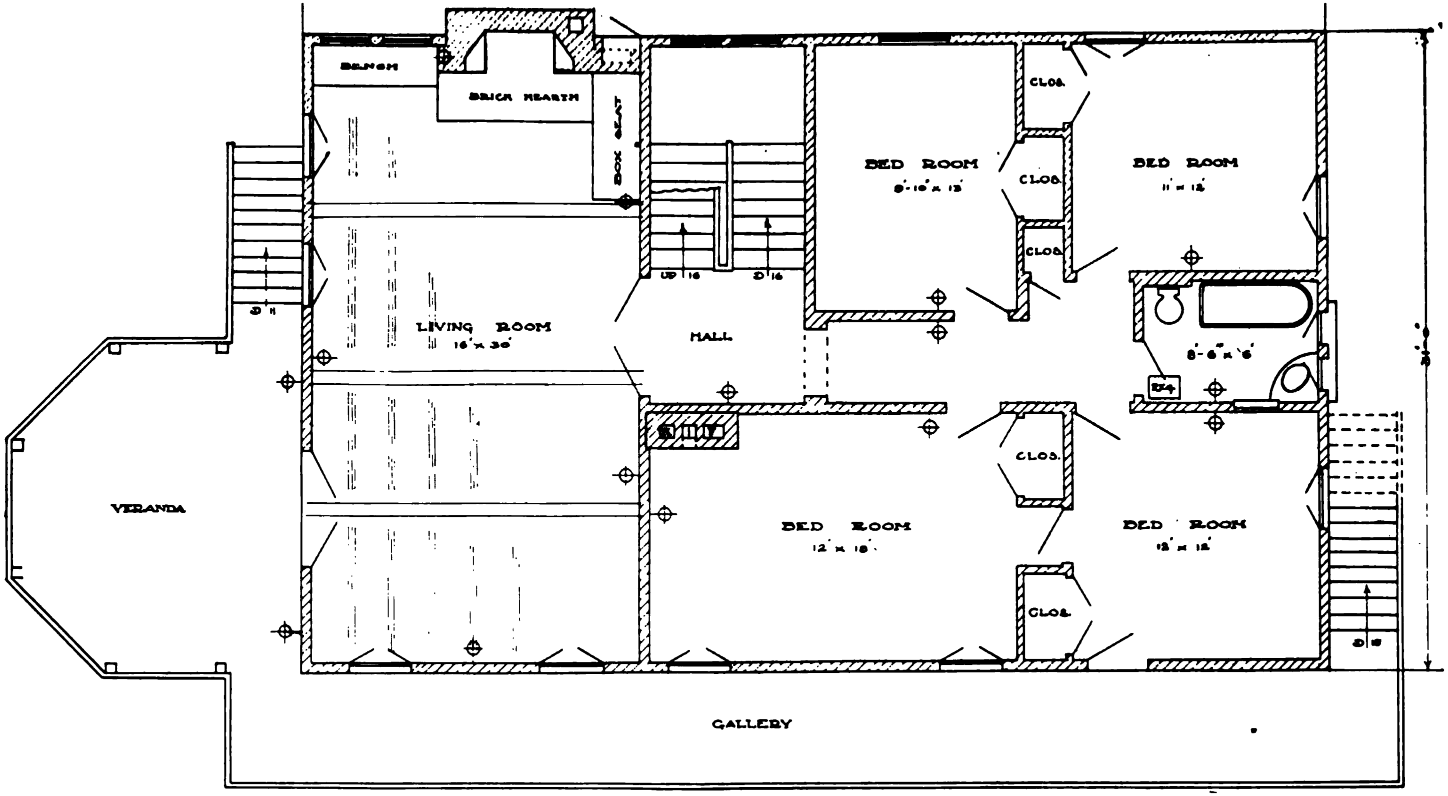


GROUND FLOOR PLAN

SUMMER COTTAGE FOR THE MISSES DUMMER AT HARBOR POINT, MICH. POND & POND, ARCHITECTS CHICAGO, ILL.

Built in 1902. Cost, $7,300. For Exterior, see Plate Opposite Foreword in this Volume; for Living Room, see Page 86.



FIRST FLOOR PLAN

SUMMER COTTAGE FOR THE MISSES DUMMER AT HARBOR POINT, MICH. POND & POND, ARCHITECTS

Ground-Floor Plan Shown on Opposite Page.

posts, it is less effective than the girt, and consequently a wall in which it has been substituted for the girt is not as stiff as one in which the girt is used.

Plate. The plate serves two purposes: First, to tie the studding together at the top and form a finish for the wall; and second, to furnish a support for the lower ends of the rafters. See Fig. 106. It is thus a connecting link between the wall and the roof, just as the sill and the girts are connecting links between the floors and the wall. Sometimes the plate is also made to support the attic floor joists, as shown in Fig. 107, in which *A* is a rafter, *B* the joist spiked to the rafter, *C* the plate built up from 2 × 4-inch pieces, and *D* the wall stud. It acts in this case like a girt, but this arrangement is not very common, the attic floor joists usually being supported on a ledger board, as shown in Fig. 105. The plate is merely spiked to the corner posts and to the top of the studding; but at the corner where the plates in two adjacent walls come together, they should be connected by a framed joint, usually halved together in the same way as the sill. In the braced frame, a fairly heavy piece, usually a 4×6 inch is used, although a 4 × 4 inch is probably sufficiently strong. In a balloon frame the usual practice is to use two 2×4-inch pieces placed one on top of the other and breaking joints, as shown at *A*

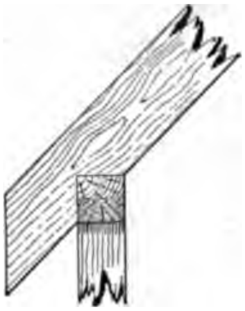


Fig. 106. Section of Plate between Studs and Rafters

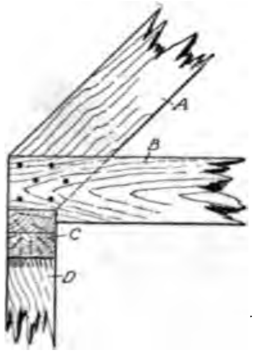


Fig. 107. Plate as Support for Attic Floor

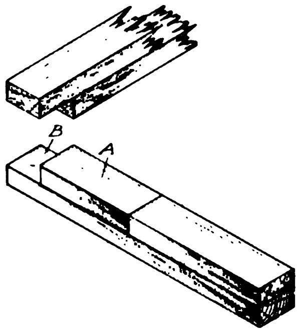


Fig. 108. Plates Used in Balloon Framing

in Fig. 108, in order to form a continuous piece. The corner joint is then formed, as shown at *B*. No cutting is done on the plate except at the corners, the rafters and the attic floor joists being cut over it, as shown in Figs. 107 and 109.

Braces. Braces are used as permanent parts of the structure only in braced frames, and serve to stiffen the wall, to keep the corners square and true, and to prevent the frame from being distorted by lateral forces, such as wind. In a full-braced frame, a brace is placed wherever a sill, girt, or plate makes an angle with a corner post, as shown at *E* in Fig. 90. Braces are placed so as to make an angle of forty-five degrees with the post, and should be long enough to frame into the corner post at a height of from one-third to one-half the height of the story. This construction is often modified in practice, and the braces are placed as shown at *A* in Fig. 109. Such a frame is not quite so stiff and strong as the regular braced frame, but it is sufficiently strong in most cases.

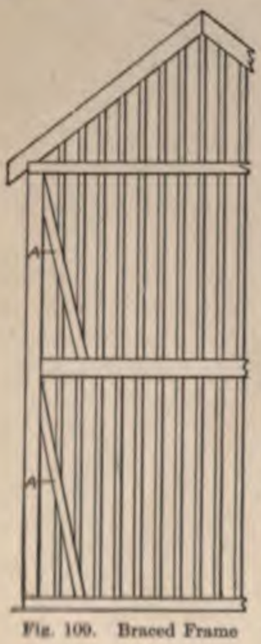


Fig. 109. Braced Frame

The braces are made the same width as the posts and girts, usually 4 inches, to be flush with these pieces both outside and inside, and are made of 3×4-inch or 4×4-inch stuff. They are framed into the posts and girders or sills, by means of a tenon cut in the end of the brace, and a mortise cut in the post or girt, and are secured by a hardwood pin. The pin should be $\frac{3}{4}$ or $\frac{7}{8}$ inch in diameter. The connection is shown in Fig. 102.

In a balloon frame there are no permanent braces, but light strips are nailed across the corners while the framework is being erected, and before the boarding has been put on, to keep the frame in place. As soon as the outside boarding is in place these are removed. This practice is also modified, and sometimes light braces are used as permanent parts of even a balloon frame. They are not framed into the other members, however, but are merely notched into them and spiked, as shown in Fig. 110. *A* is the brace, *B* the sill, *C* the corner post, and *DD* are studs. In such a case every stud must be notched to receive the brace, which is really the same as the temporary brace mentioned above, except that it is notched into the studs instead of being merely nailed to them, and is not removed when the boarding is put on. These braces are usually made of 1×3-inch stuff.

Studding. When the sill, posts, girts, plates, and braces are in place, the only step that remains to complete the rough framing of the wall is the filling in of this framework with studding. The studding is of two kinds, viz, the heavy pieces which form the frames for the door and window openings and the stops for the partitions; and the lighter pieces which are merely "filling-in" studs, and are known by that name, or as "intermediate" studding.

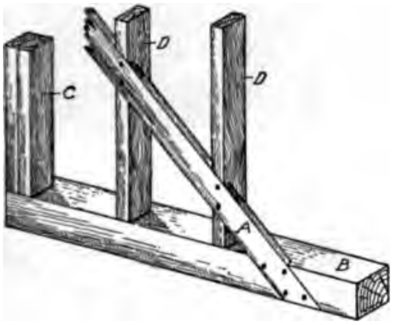


Fig. 110. Light Braces for Balloon Frame

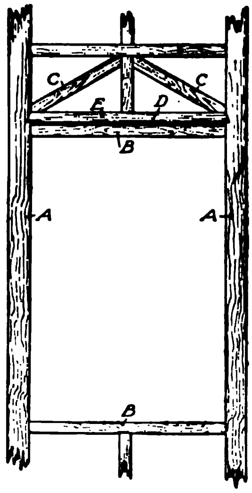


Fig. 111. Construction of Door and Window Frames

The frames for the door and window openings are usually made in a braced frame, from 4×4-inch pieces. A vertical stud *AA*, Fig. 111, is placed on each side of the opening, the proper distance being left between them, and horizontal pieces *BB* are framed into them at a proper level to form the top and the bottom of the opening. In all good work a small truss is formed above each opening by setting up two pieces of studding *CC* over the opening, in the form of a triangle. This is to receive any weight which comes from the studding directly above the opening, and to carry it to either side of the opening where it is received by the studding and in this way carried down to the sill. Such a truss is shown in Fig. 111. The pieces used are 3×4 inches or 4×4 inches, and may be either framed into the other members or merely spiked. There should be a space *D* of at least 1 inch between the piece *B* forming the top of the window frame and the piece *E* forming the bottom of the truss, so that if the truss sags at all it will not affect the window frame. This is a point that is not generally recognized. The piece *B* is usually made to serve both as the top of the window and bottom of the truss.

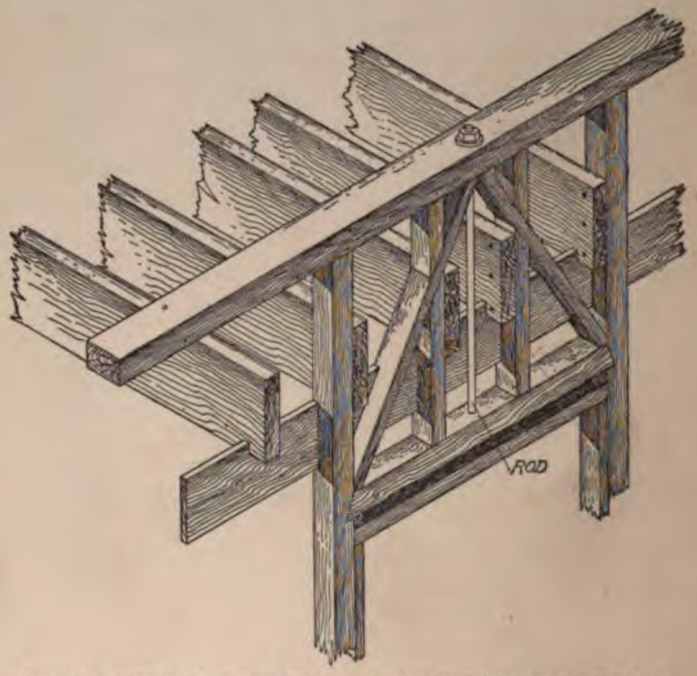


Fig. 112. Framing Details of Window Opening in Balloon Frame Building

Fig. 112 shows the framing for the top of a window opening in a balloon-framed building, where the ledger board is partly supported by the studs directly over the opening. Since the floor joists rest on the ledger board, there may be considerable weight transferred to these studs; and in order to prevent the bottom of the truss from sagging under this weight, an iron rod should be inserted as shown.

In the balloon frame, the door and window studs are almost always made of two 2×4-inch pieces placed close together, and in this case the connection of the piece forming the top and bottom of the frame with those forming the sides is made as shown at *A* in Fig. 113. It should be noticed that in a balloon frame all studding is carried clear up from the sill to the plate, so that if there is an opening in the wall of the first story, and no corresponding openings in those of the second or third story, the door and window studding must still be carried double, clear up to the plate, and material is thus wasted. In designing for balloon frames, therefore, it is well to take care that the window openings in the second story come directly above those in the first story wherever this is possible. The same difficulty does not occur in the case of a braced frame, because in such a frame the studding in each story is independent of that in the story above or below it; the window openings may, therefore, be arranged independently in the different stories according to the requirements of the design.

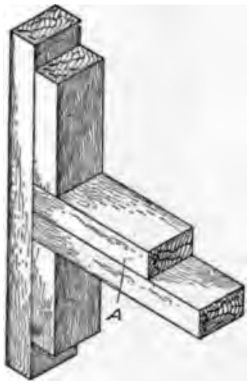


Fig. 113. Door and Window Studs in Balloon Frame

Nailing Surfaces. Whenever a partition meets an outside wall, a stud wide enough to extend beyond the partition on both sides and to afford a solid nailing for the lathing must be inserted. A nailing surface must be provided for the lathing on both the outside wall and the partition, and the first stud in the partition wall is, therefore, set close up against the wall stud, forming a solid corner. This arrangement is shown in plan in Fig. 114. The large wall stud *A* is usually made of a 4×8-inch piece set flatwise in the wall, so that if the partition is, say 4 inches wide, there is a clear nailing surface of 2 inches on each side of the partition. A 4×6-inch piece could also be used here, leaving a clear nailing surface of 1 inch on each side of the partition.

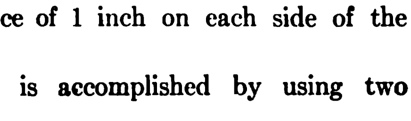


Fig. 114. Plan of Studding in Outer Wall Opposite Partition

Sometimes the same thing is accomplished by using two

4×4-inch pieces placed close together, as shown in plan in Fig. 115, instead of one 4×8-inch piece. Sometimes two pieces, 2×4 inches or 3×4 inches, are used, placed far enough apart so that they afford a space for nailing on each side of the partition, as shown in plan in Fig. 116. Whenever this is done, small blocks *A*, Fig. 117, should be set in between the two studs at intervals of 2 to 3 feet throughout their entire height in order to give them added stiffness and make them act together.

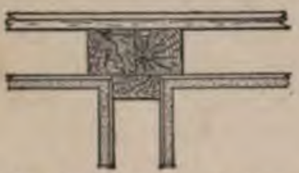


Fig. 115. Two-Piece Stud in Outer Wall Opposite Partition

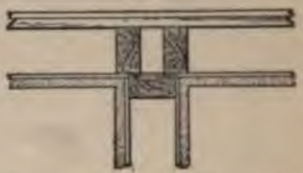


Fig. 116. Placing of 2×4 Studs to Give Nailing Surface

The end in view in every case is to obtain a solid corner on each side of the partition where it joins the wall, and any construction which accomplishes this is good. In the best work, however, the 4×8-inch solid piece is used, and this construction can always be depended upon. It makes no difference what the angle between the wall and the partition may be, but usually this angle is a right angle.

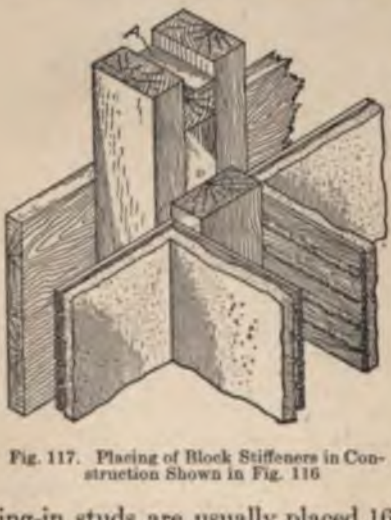


Fig. 117. Placing of Block Stiffeners in Construction Shown in Fig. 116

Intermediate Studding. The pieces which make up the largest part of the wall frame are the "filling-in" or "intermediate" studs. These, as the name implies, are used merely to fill up the frame made by the other heavier pieces, and afford a nailing surface for the boarding, which covers the frame on the outside, and the lathing, which covers it on the inside. The filling-in studs are usually placed 16 inches apart, measured from the center of one stud to the center of the next. In especially good work they are sometimes placed only 12 inches apart on centers, but this is unusual. In no case should they be placed more than 16 inches apart, even in the lightest work. The studs are made the full width of the wall, usually 4 inches, but sometimes in large buildings (such as churches) 5 or even 6 inches and their thickness is almost always 2 inches, 2×4 inches being the more usual dimensions. The lengths of the intermediate studs are made to fit the rest of the frame.

In the braced frame, there must necessarily be a great deal of cutting of the intermediate studding, because all the large pieces are made the full width of the wall and the intermediate studding must be cut to fit between them. In the balloon frame, however, the intermediate studding in all cases extends clear up from the sill to the plate, and no cutting is necessary except the notching to receive the other parts of the frame. See Fig. 91.

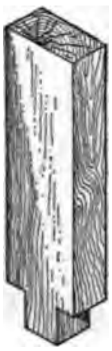


Fig. 118. Intermediate Stud with Tenon

In a balloon frame it often happens that the studs are not long enough to reach from the sill to the plate and they must be pieced out with short pieces which are spliced onto the long stud. This splicing is called "fishing," and it is accomplished by nailing a short thin strip of wood *AA* on each side of the stud, as shown in Fig. 54, in order to join the two pieces firmly together. The strips should be well nailed to each piece in order to give the required strength.

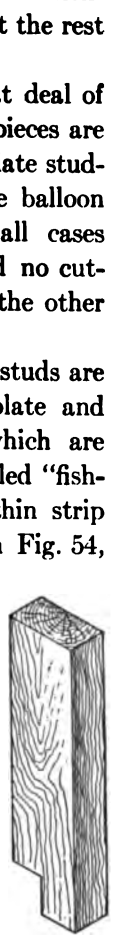


Fig. 119. Intermediate Stud with Tenon

All door and window studs should have a tenon cut at the foot of the piece to fit a mortise cut in the sill. Intermediate studs are merely spiked to the sill without being framed into it. The tenons are cut in two different ways, as shown in Figs. 118 and 119. They are always made the full thickness of the piece, and by the first method they are placed in the middle of the piece, as shown. The width of the tenon is about 1½ inches, leaving 1½ inches on the outside and 1 inch on the inside of the stud. Another way is to make the tenon on the inside of the stud, as shown in Fig. 119, the tenon being 1½ inches wide as before. There is no choice between these methods, both being good.

PARTITIONS

The studding used in partition walls is usually of 2×4-inch stuff, although 2×3-inch studding may sometimes be used to advantage if the partition does not support any floor joists.

Furring Walls. The partition walls are made 4 inches wide, the same as in the outer walls, except in the case of so-called "furring" partitions. These are built around chimney breasts and serve to conceal the brickwork and furnish a surface for plastering. They are formed by placing the studding flatwise, in order to make a thin wall; and as it is usually specified that no woodwork shall come within 1 inch of any chimney, a 1-inch space is left between the brickwork and the furring wall. It is possible to apply the plaster directly to the brickwork, and this is sometimes done, but there is always danger that cracks will appear in the plastering at the corner *A*, Fig. 120, between the chimney breasts and the outside wall. This cracking is due to the unequal settlement of the brickwork and the woodwork since the plastering goes with the wall to which it is

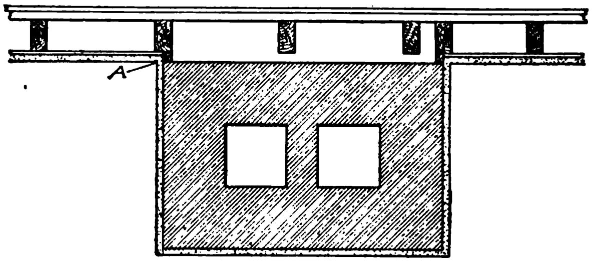


Fig. 120. Plan Showing Plaster Applied Directly to Chimney Brickwork

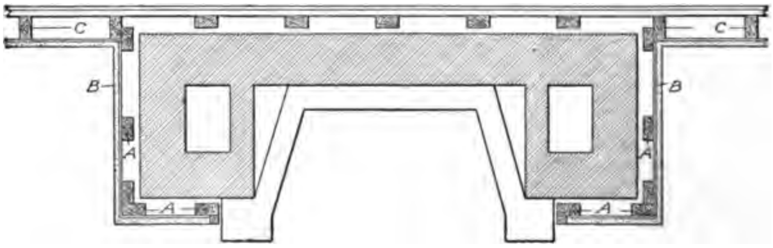


Fig. 121. Plan Showing Construction of Furring Wall

applied. The method of constructing a furring wall is shown in plan in Fig. 121. *AA* are the furring studs, *B* is the plastering, and *CC* the studding in the outside wall. The arrangement without the furring wall is shown in plan in Fig. 120. If there are any openings in the furring wall, such as fireplaces, or "thimbles" for stove pipes, it is necessary to frame around them in the same way as was explained for door and window openings in the outside walls. See Fig. 122. *AA* are furring studs, *BB* are pieces forming the top and bottom of the opening.

If the outside walls of the building are of brick or stone, a wood "furring" wall is usually built just inside of the outer wall; this furnishes a surface for plastering and for nailing the inside finish. The studding for these walls is 2 × 4 inches or 2 × 3 inches or 1×2 inches set close up against the masonry wall and preferably spiked to it. See Fig. 123. Spikes are usually driven directly into the mortar between the bricks or stones of the wall, but sometimes wood blocks or wedges are inserted in the wall to afford a nailing surface.

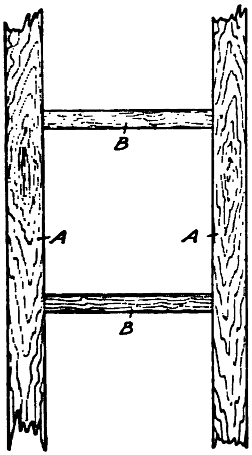


Fig. 122. Furring Strip Frames Around Openings

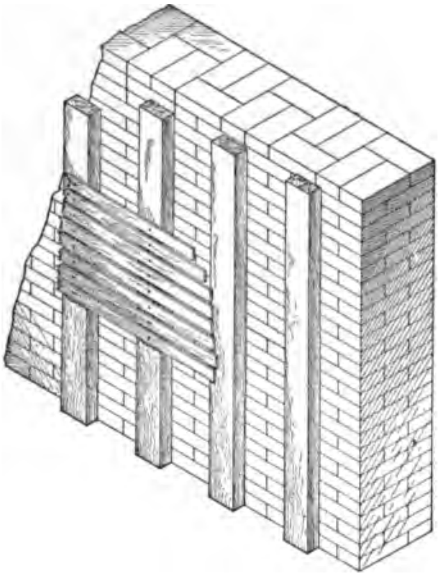


Fig. 123. Furring strips on Outside Wall

Wherever a wood partition wall meets a masonry exterior wall at an angle, the last stud of the partition wall should be securely spiked in the masonry wall, to prevent cracks in the plastering.

Cap and Sole. All partition walls are finished at the top and bottom by horizontal pieces, called, respectively, the "cap" and the "sole." The sole rests directly on the rough flooring whenever there is no partition under the one which is being built; but if there is a partition in the story below, the cap of the lower partition is used as the sole for the one above. The sole is made wider than the studding forming the partition wall, so that it projects somewhat on each side and gives a nailing surface for the plasterer's grounds and for the inside finish. It is usually made about 2 inches thick and 5½ inches wide, when the partition is composed of 4-inch studding, and this leaves a nailing surface of ¾ of an inch on each side. The sole is shown at *B* in Fig. 124. The cap is usually made the same width as the studding, and 2 inches thick, so that a 2×4-inch piece may be used in most cases; but if the partition is called upon to support the floor beams of the floor above, the cap may have to be made 3 or even 4 inches thick, and some architects favor the use of hard wood such as Georgia pine for the partition caps. The cap is shown at *A*, Fig. 125.

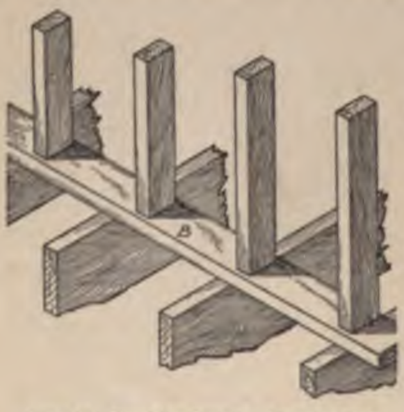


Fig. 124. Partition Framing Showing Sole

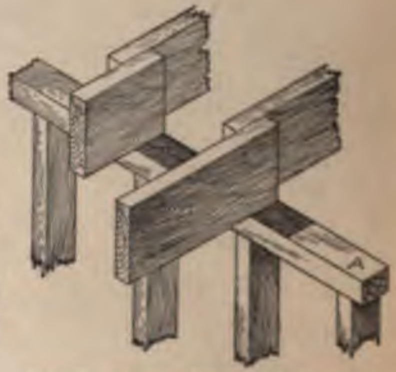


Fig. 125. Partition Framing Showing Cap

Bridging. In order to stiffen the partitions, short pieces of studding are cut in between the regular studding in such a way as to connect each piece with the pieces on each side of it. Thus, if one piece of studding is for any reason excessively loaded, it will not have to carry the whole load alone but will be assisted by the other pieces. This operation is called "bridging," and there are two kinds, which may be called "horizontal bridging" and "diagonal bridging." The horizontal bridging consists of pieces set in horizontally between the vertical studding to form a continuous horizontal line across the wall, every other piece, however, being a little above or below the next piece as shown in Fig. 126. The pieces are 2 inches thick and the full width of the studding; and in addition to strengthening the wall, they prevent fire or vermin from passing through, and also may be utilized as a nailing surface for any inside finish such as wainscoting or chair rails.

The second method, which we have called diagonal bridging, is more effective in preventing the partition from sagging than is the straight bridging, but both methods may be used with equal propriety. In the diagonal bridging the short pieces are set in diagonally, as is shown in Fig. 127, instead of horizontally, between the vertical studding. This method is certainly more scientific than the other, since a continuous truss is formed across the wall.

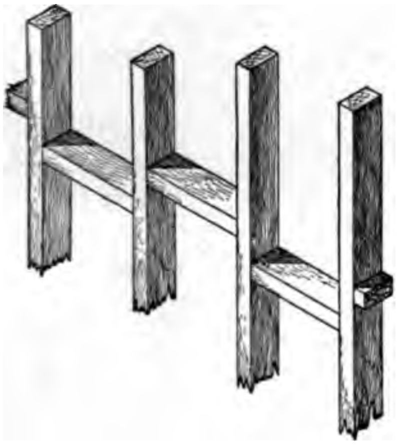


Fig. 126. Horizontal Bridging

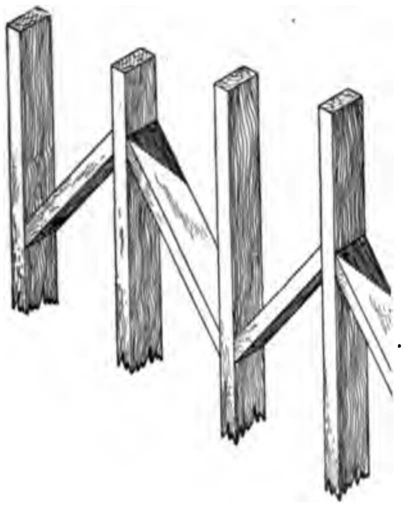


Fig. 127. Diagonal Bridging

All partitions should be bridged by one of these methods, at least once in the height of each story, and the bridging pieces should be securely nailed to the vertical studding at both ends. It is customary to specify two tenpenny nails in each end of each piece. Bridging should be placed in the exterior walls as well as in the partition walls; and as a further precaution against fire, it is good practice to lay three or four courses of brickwork, in mortar, on the top of the bridging in all walls, to prevent the fire from gaining headway in the wall before burning through and being discovered. This construction is shown in Fig. 128.

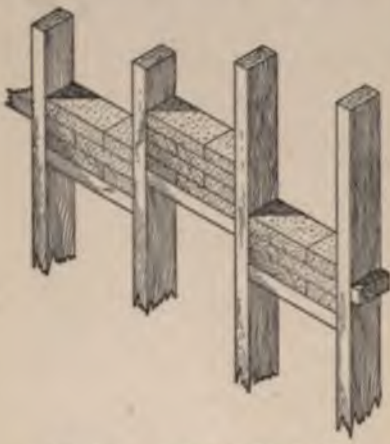


Fig. 128. Horizontal Bridging with Bricks Laid on Top

Special Partitions. A partition in which there is a sliding door must be made double to provide a space into which the door may slide when it is open. This is done by building two walls far enough apart to allow the door to slide in between them, the studding being of 2 × 4-inch or 2×3-inch stuff, and placed either flatwise or edgewise in the wall. If the studding is placed flatwise in the wall a thinner wall is possible, but the construction is not so good as in the case where the studs are placed edgewise. If the partition is to support a floor, one wall must be made at least 4 inches thick to support it, and the studs in the other wall may then be placed flatwise if desired, and the floor supported entirely on the thick wall. The general arrangement is shown in plan in Fig. 129. It is better to use 2 × 4-inch studding set edgewise in each wall so as to make two 3-inch walls with space enough between to allow the door to slide freely after the pocket has been lined with sheathing.

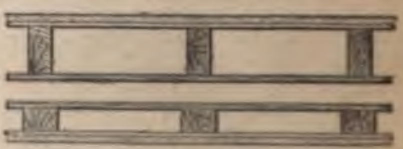


Fig. 129. Section of Partition Construction for Sliding Doors

A piece of studding *A*, Fig. 130, should be cut in horizontally between each pair of studs *B*, 8 or 10 inches above the top of the door in order to keep the pocket true and square. The pocket should be lined on the inside with matched sheathing *C*.

It is well known that ordinary partitions are very good conductors of sound; and in certain cases, as in tenement houses, this is objectionable, so that special construction is required. If two walls are built entirely separate from each other and not touching at any place, the transmission of sound is much retarded; and if heavy felt paper or other material is put in between the walls, the partition is made still more nearly soundproof. In order to decrease the thickness of such a wall as much as possible, the "staggered" partition is used, in which there are two sets of studding, one for each side of the wall, but arranged alternately instead of in pairs as in the double partition. The arrangement is shown in plan in Fig. 131. The two walls are entirely separate from each other and the felt paper may be worked in between the studs as shown, or the whole space may be packed full of some soundproof and fireproof material such as mineral wool. There is a so-called "quilting paper" or "sheathing-quilt" manufactured from sea weed, which is much used for this purpose. The inside edges of the two sets of studs are usually placed on a line, making the whole wall 8 inches thick, where 4-inch studding is used, and the studs may be placed about 16 inches on centers in each wall. Each set of studding should be bridged separately.

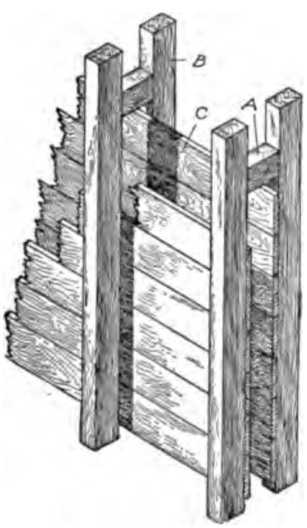


Fig. 130. Details of Bracing in Double Partition

Another case where a double wall may be necessary, is where pipes from heaters or from plumbing fixtures are to be carried in the wall. In case of hot pipes, care must be taken to have the space large enough so that the woodwork will not come dangerously near the pipes.

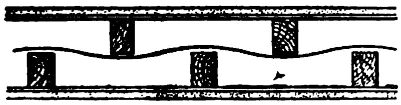


Fig. 131. Partition with Stagger Studding to Prevent Sound Transmission

An important matter in connection with the framing of the partitions is the way in which they are supported; but this involves knowledge of the framing of a floor and, therefore, it will be left for the present. It will be taken up after we have considered the floor framing.

SHRINKAGE AND SETTLEMENT

An important point which must be considered in connection with the framing of the walls and partitions, is the settlement due to the shrinkage of timber as it seasons after being put in place. Timber always shrinks considerably ACROSS the grain, but very little in the direction of the grain; so it is the horizontal members, such as the sills, girts, and joists, which cause trouble, and not the vertical members, such as posts and studding. Every inch of horizontal timber between the foundation wall or interior pier and the plate is sure to contract a certain amount, and as the walls and partitions are supported on these horizontal members, they, too, must settle somewhat. If the exterior and interior walls settle by exactly the same amount, no harm will be done, since the floors and ceilings will remain level and true, as at first; but if they settle unequally, all the levels in the building will be disturbed, and the result will be cracking of the plastering, binding of doors and windows, and a general distortion of the whole frame, a condition which must be avoided if possible.

It is evident that one way to prevent unequal settlement, so far at least as it is due to the shrinkage of the timber, is to make the amount of horizontal timber in the exterior and interior walls equal. Thus, starting at the bottom, we have from the masonry of the foundation wall to the top of the first floor joists in the outside walls 10 inches, or the depth of the joists themselves, since these rest directly on the top of the wall. In the interior, we have, if the joints are framed flush into a girder of equal depth, the same amount, so that here the settlement will be equal. But the studding in the exterior wall rests, not on the top of the joists, but on the top of the 6-inch sill, while the interior studding rests on top of the 10-inch girder. Here is an inequality of 4 inches which must be equalized before the second floor level is reached. If the outer ends of the second-floor joists rest on the top of an 8-inch girt, and the inner ends on a 4-inch partition cap, this equalizes the horizontal timber inside and outside, and the second floor is safe against settlement. The same process of equalization of the horizontal timber may be continued for each floor up to the top of the building, and if this is carefully done it will go far toward preventing the evils resulting from settlement and shrinkage.

With a balloon frame this can not be done, because there are no girts in the outside wall, but only ledger boards which are so fastened that they can not shrink, while in the interior walls we have still the partition caps. All that can be done in this case, is to make the depth of the sills and interior girders as nearly equal as possible, and to make the partition caps as shallow as will be consistent with safety.

FLOORS

After the wall, the next important part of the house frame to be considered is the floors, which are usually framed while the wall is being put up and before it is finished. They must be made not only strong enough to carry any load which may come upon them, but also stiff enough so that they will not vibrate when a person walks across the floor, as is the case in some cheaply-built houses. The floors are formed of girders and beams, or "joists," the girders being large, heavy timbers which support the lighter joists when it is impossible to allow these to span the whole distance between the outside walls.

Girders. Girders are generally needed only in the first floor, since in all the other floors the inner ends of the joists may be supported by the partitions of the floor below. They are usually of wood, though it may sometimes be found economical to use steel beams in large buildings, and even in small buildings the use of steel for this purpose is increasing rapidly. Wrought iron was once used, but steel is now cheaper and has taken its place. However, when this is not found to be expedient, hard pine or spruce girders will answer very well. The connections used in the case of steel girders will be explained later. The girders may be of spruce or even of hemlock, but it is hard to get the hemlock in such large sizes as would be required, and spruce, too, is hardly strong enough for the purpose. Southern pine, therefore, is usually employed for girders in the best work.

The size of the girder depends on the span, that is, the distance between the supporting walls, and upon the loads which the floor is expected to carry. In general, the size of a beam or girder varies directly as the square of the length of the span, so that if we have two spans, one of which is twice as great as the other, the girder for the longer span should be four times as strong as the girder for the smaller span. In ordinary houses, however, all the girders are made about 8×12 inches in sections, although sometimes an 8×8-inch timber would suffice, and sometimes perhaps a 12-inch piece would be required.

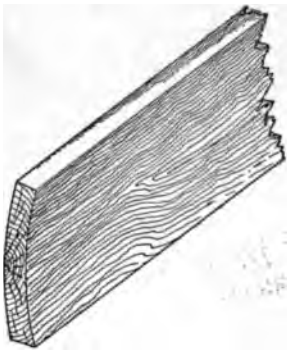


Fig. 132. Buckled Girder Showing Too Light Construction

It should be remembered in deciding upon the size of this piece, that any girder is increased in strength in direct proportion to the width of the timber (that is, a girder 12 inches wide is twice as strong as one 6 inches wide), but in direct proportion also to the square of the depth (that is, a girder 12 inches deep is four times as strong as one 6 inches deep). Hence, the most economical girder is one which is deeper than it is wide, such as an 8×12-inch stick; and the width may be decreased by any amount so long as it is wide enough to provide sufficient stiffness, and the depth is sufficient to enable the piece to carry the load placed upon it. If the piece is made too narrow in proportion to its depth, however, it is likely to fail by "buckling," that is, it will bend as shown in Fig. 132. It has been found by experience that for safety the width should be at least equal to ⅙ of the depth.

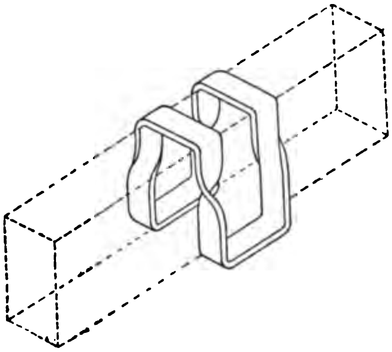


Fig. 133. Double Stirrup Joist Supporter

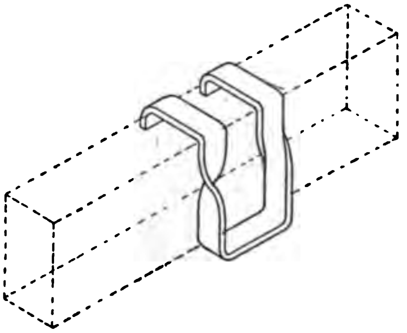


Fig. 134. Single Joist Hanger

There are at least three ways in which the joists may be supported by a girder. The best, but most expensive, method is to

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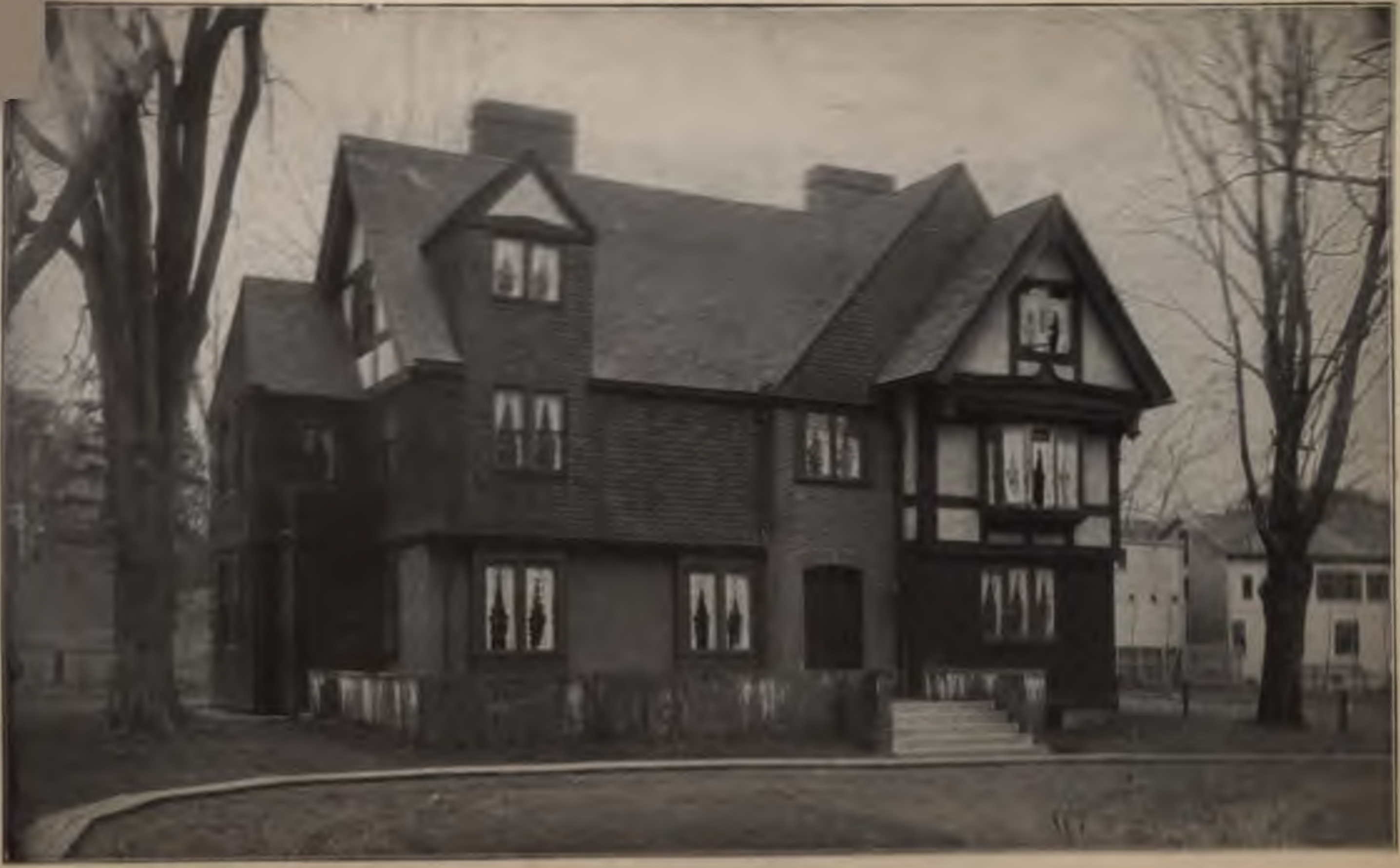
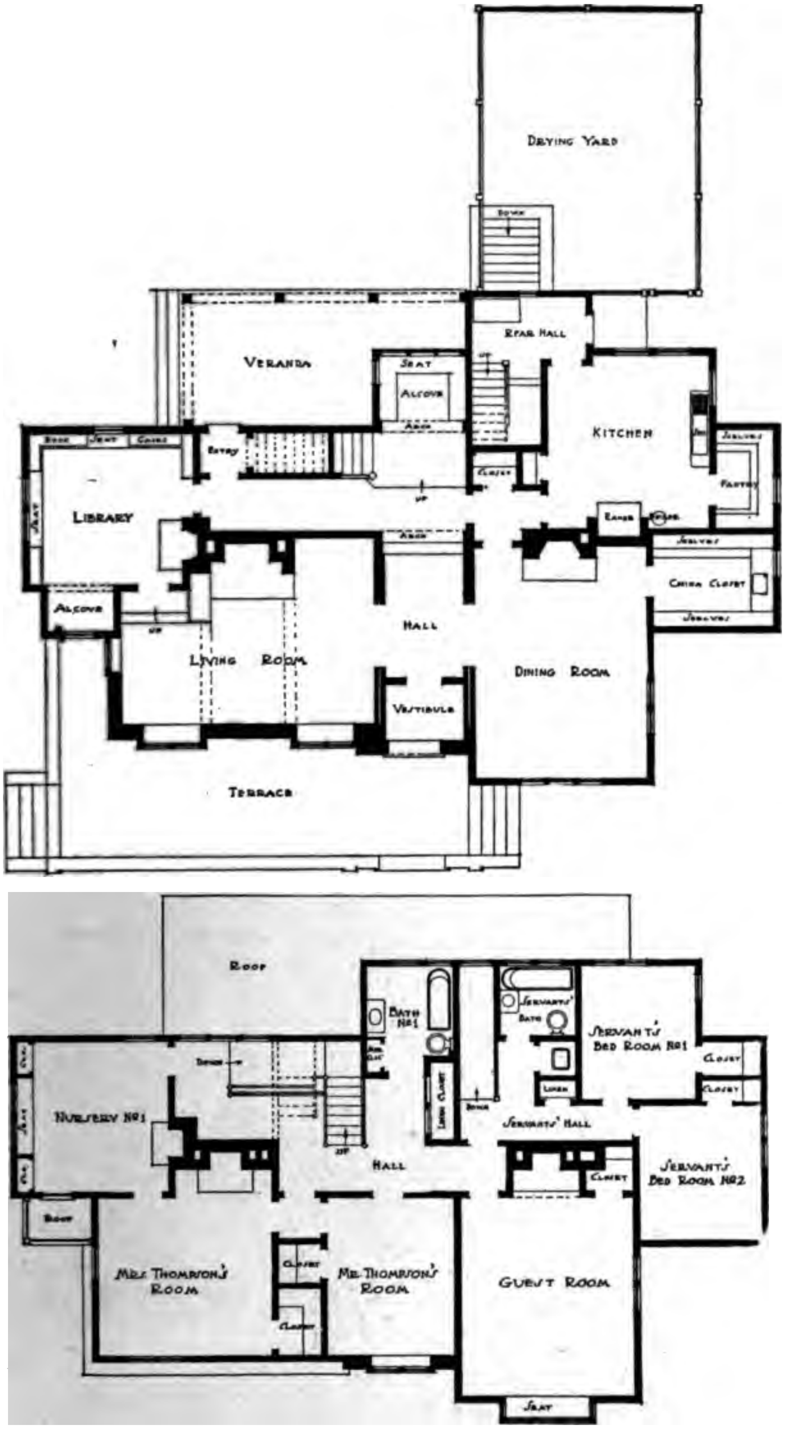


HOUSE FOR MR. C. M. THOMPSON, CAMBRIDGE, MASS.

Cram, Goodhue & Ferguson, Architects, Boston and New York

The Seven General Contract Estimates Ran from $18,715 down to $11,789. The House was Built at the Latter Figure, plus a Great Many Extras Added by the Owner; and to this Amount was Added $2,380 for Plumbing and Heating. It was Built in 1900. The House Faces about South.

For Interiors, See Pages [illegible], [illegible], and [illegible].



FIRST AND SECOND STORY PLANS OF HOUSE FOR
MR. C. M. THOMPSON, CAMBRIDGE, MASS.
Cram, Goodhue & Ferguson, Architects, Boston and New York.

support the ends of the joists in patent hangers or stirrup irons which connect with the girder. This method is the same as was described for the sill, except that with the girder a double stirrup iron, such as that shown in Fig. 133, may be used. These stirrup iron hangers are made of wrought iron, 2½ or 3 inches wide, and about ⅜ inch thick, bent into the required shape. They usually fail by the crushing of the wood of the girders, especially when a single hanger, like that shown in Fig. 134, is used. Fig. 135 shows a double stirrup iron hanger in use. Patent hangers as shown in Fig. 136 are the most suitable.

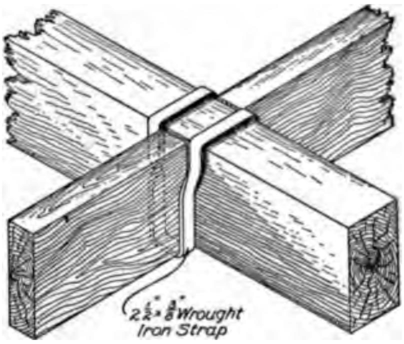


Fig. 135. Double Hanger with Joists in Place

If hangers of any kind are used, there will be no cutting of the girder except at the ends, where it frames into the sill, and even there a hanger may be used. The girder may be placed so that the joists will be flush with it on top, or so that it is flush with the sill on top.

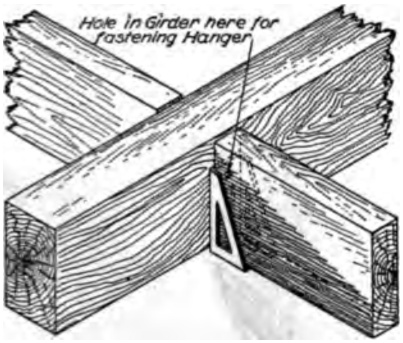


Fig. 136. Patent Hanger with Joists in Place

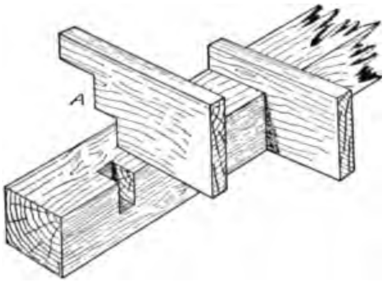


Fig. 137. Joists Framed into Sill

If the joists are flush with the girder on top, and are framed into the sill in the ordinary way, as shown in Fig. 137, the girder can not be flush on top with the sill; while, on the other hand, if the girder is flush with the sill on top, it can not at the same time be flush with the joists on top. If joist hangers are used on the girder to support the joists, they will probably be used on the sill as well, as explained in connection with the sill; and in this case the girder can be made flush with the sill on top and the joists hung from both girder and sill with hangers, thus bringing both ends of a joist to the same level, as shown in Fig. 138. If the girder were framed into the sill at all, it would almost always be made flush with the sill on top, and by the proper adjustment of the hangers the joists would be arranged so as to be level.

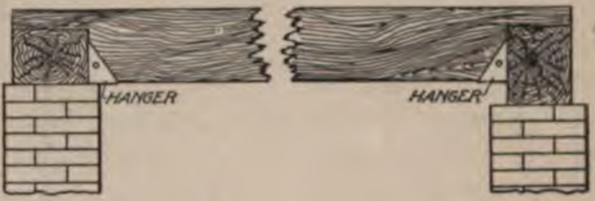


Fig. 138. Method of Bringing Joist Level When Resting on Sill

For framing the girder into the sill, a tenon-and-tusk joint, as shown in Fig. 139, would be used if the girder is to be flush with the sill on top. Since the girder would in most cases be deeper than the sill, the latter having a depth of only 6 inches the wall would necessarily have to be cut away in order to make a place for the girder. This condition is clearly shown in Fig. 140. The girder itself should not be cut over the wall, as shown in Fig. 141, because this greatly weakens the girder. If this method is used, the joists should be framed into the girder in the same way as they are framed into the sill, a mortise being cut in the girder, and a tenon on the joist. This is called "gaining" and is shown in Fig. 137. The top of the girder thus comes several inches below the top of the floor.

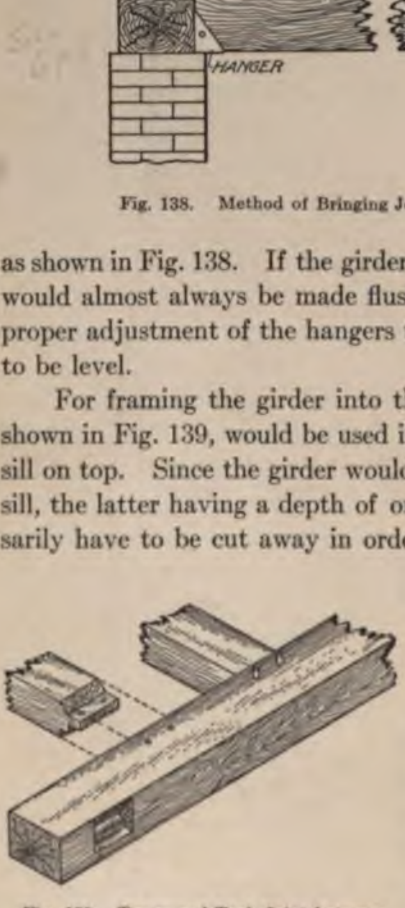


Fig. 139. Tenon-and-Tusk Joint between Sill and Girder

Another method is to make the top of the girder flush with the top of the joists. The joists are then framed into the girder with a tenon-and-tusk joint, as shown in Fig. 139, and the girder is "gained" into the sill, as shown in Fig. 137.

Still another method in common use is simply to "size down" the joists on the girder about 1 inch, as shown in Fig. 142. In this case, of course, the girder is much lower than the sill, usually so low that it can not be framed into the sill at all, but must be supported by the walls independently. Holes are left in the wall where the girders come, the latter being run into the holes, and their ends resting directly on the wall, independent of the sill. This is not very good construction, however, because the floor is not tied together as it is when the girder frames into the sill. The first method is the best and is the one in most common use.

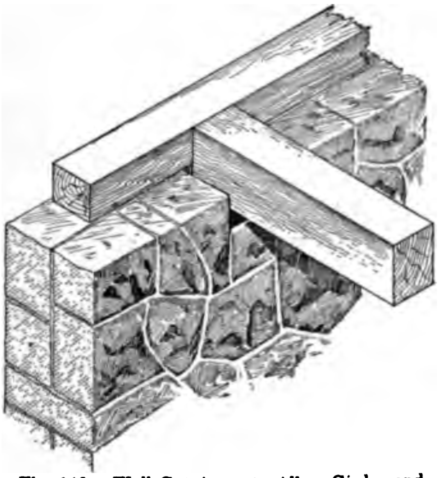


Fig. 140. Wall Cut Away to Allow Girder and Sill to Join at Same Level

The girders serve to support the partitions as well as to support the floors, and should, therefore, be designed to come under the partitions whenever this is possible. When the distance between the outside walls is too great to be spanned by the girder, it is supported on brick piers or posts of hard wood or cast iron in the cellar. Such piers or posts should always be placed wherever girders running in different directions intersect. Girders are also often supported on brick cellar partitions.

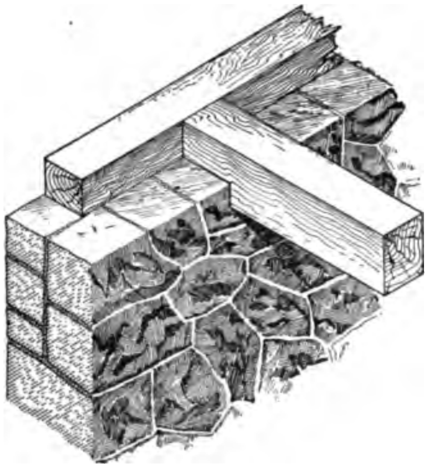


Fig. 141. Cutting Girder Bad Practice on Account of Weakening Effect

Joists. Joists are the light pieces which make up the body of the floor frame and to which the flooring is nailed. They are almost always made of spruce, although other woods may be used, and may be found more economical in some localities. They are usually 2 or 3 inches thick, but the depth is varied to suit the conditions. Joists as small as 2×6 inches are sometimes used in very light buildings, but these are too small for any floor. They may sometimes be used for a ceiling where there are no rooms above, and, therefore, no weight on the floor. A very common size for joists is 2×8 inches, and these are probably large enough for any ordinary construction, but joists 2×10 inches make a stiffer floor, and are used in all the best work. Occasionally joists as large as 2×12 inches are used, especially in large city houses, and they make a very stiff floor, but this size is unusual. If a joist deeper than 12 inches is used, the thickness should be increased to 2½ or 3 inches, in order to prevent it from failing by buckling, as explained for girders, P. 95. The size of the joists depends in general upon the span and the spacing.

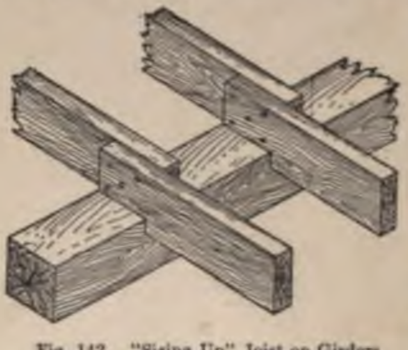


Fig. 142. "Sizing Up" Joist on Girders

The usual spacing is 16 or 20 inches between centers, and 16 inches makes a better spacing than 20 inches, because the joists can then be placed close against the studding in the outside walls and spiked to this studding. It is generally better to use light joists spaced 16 inches on centers than to use heavier ones spaced 20 inches on centers. The spacing is seldom less than 16 inches and should never be more than 20 inches.

Supports and Partitions. In certain parts of the floor frame it may be necessary to double the joists or place two of them close together in order to support some very heavy concentrated load. This is the case whenever a partition runs parallel with the floor joists, unless there is another partition under it. Such partitions may be supported in several different ways. A very heavy joist, or two joists spiked together, may be placed under the partition, as shown at *A* in Fig. 143, *C* being the sole, *B* the under or rough flooring, and *DDD* the studding. This method is objectionable for two reasons: It is often found convenient to run pipes up in the partition, and if the single joist is placed directly under the partition, this can not be done except by cutting the joist and thus weakening it. Moreover, if the single joist is used, there is no solid nailing for the finished upper flooring, unless the joist is large enough to project beyond the partition studding on each side. The joist is seldom, if ever, large enough for this, and the finished flooring must, therefore, be nailed only to the under flooring at the end where it butts against the partition, so that a weak, insecure piece of work is the result. This may be seen by referring to the figure.

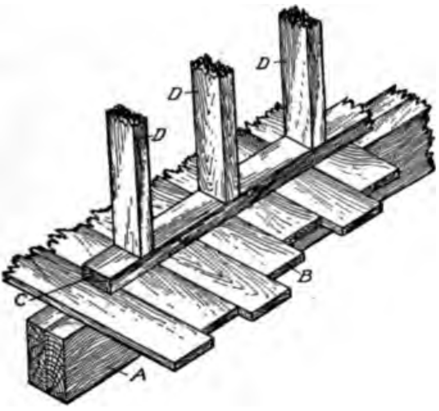


Fig. 143. Objectionable Construction for Partition Support

A much better way is to use two joists far enough apart to project a little on each side of the partition, as shown at *AA* in Fig. 144, and thus afford a nailing for the finished flooring. These joists must be large enough to support the weight of the partition without sagging any more than do the other joists of the floor, and, therefore, joists 3 or even 4 inches thick should be used. They should be placed about 6 or 7 inches apart on centers, and plank bridging should be cut in between them at intervals of from 14 to 20 inches, as shown at *E* in Fig. 144, in order to stiffen them and make them act together. This plank bridging should be made of pieces of joist 2 inches thick and of the same depth as the floor joists, and should be so placed that the grain will in every case be horizontal.

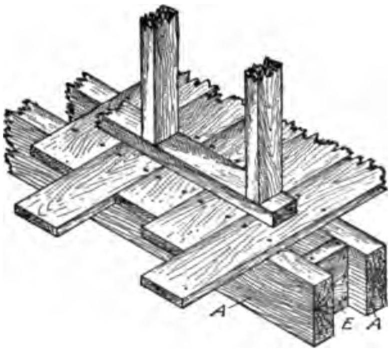


Fig. 144. Approved Construction for Partition Support

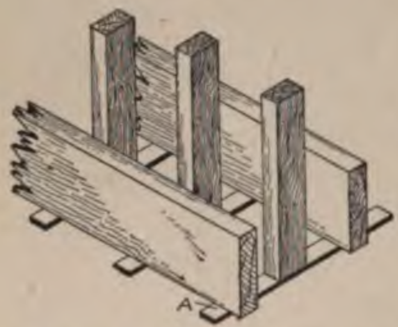


Fig. 145. Partition Supported by Strips Secured to Under Side of Joist

A partition, supported as described above, is bound to settle somewhat as the 10 or more inches of joist beneath it shrinks in seasoning, and the settlement may cause cracks in the plastering at the corner between the partition and an outside wall. In order to prevent this settlement, partitions running parallel with the floor joists are often supported on strips which are secured to the under side of the floor joists, as shown at *A* in Fig. 145. These strips can not be allowed to project into the room below, and so they must be made as thin as is consistent with safety. Strips of iron plate about ½ inch thick and wide enough to support the partition studs are, therefore, used for this purpose, and are fastened to the joists by means of bolts or lag screws. Partitions which run at right angles to the floor joists can also be supported in this way. If a partition runs at right angles to the joists near the center of their span, the tendency

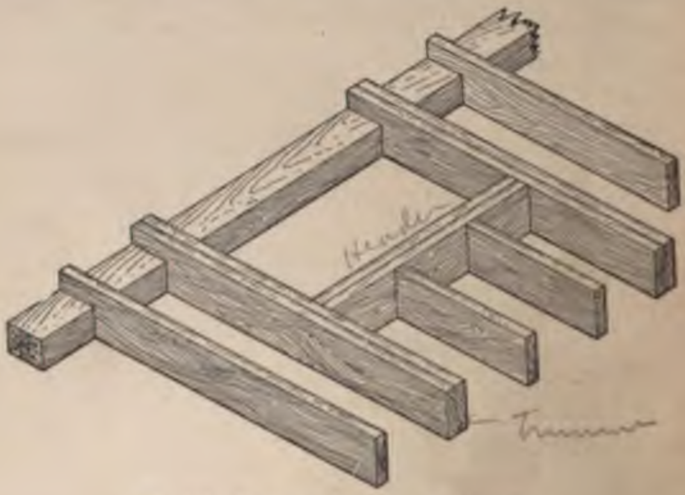


Fig. 146. Header and Trimmer Construction

for the joists to sag under it will be very great, and they must be strengthened either by using larger joists, or by placing them closer together. If the span of the floor joists is large and the partition is a heavy one, it may be necessary to put in a girder running at right angles to the joists to carry the partition. In this case the partition stud will set directly on the girder, which may be a large timber, or in some cases, a steel I-beam.

Headers and Trimmers. Another case where a girder may be necessary in a floor above the first, is where an opening is to be left in the floor for a chimney or for a stair well. The timbers on each side of such an opening are called "trimmers," and must be made heavier than the ordinary joists; while a piece called a "header" must be framed in between them to receive the ends of the joists, as shown in Fig. 146. The trimmers may be made by simply doubling up the floor joists on each side of the opening, or, if necessary, I-beams or heavy wood girders may be used. In most cases these trimmers may be built up by spiking together two or three joists, and the header may be made in the same way.

Joist Connection. *With Sill.* Joists are also "gained" into the sill, as shown in Fig. 94, in which case a mortise is cut in the sill and a corresponding tenon is cut in the end of the joist. The mortise was illustrated and described in connection with the sill, while the end of the joist is cut as shown in Fig. 94, the tenon being about 4 inches deep and gained into the sill about 2 inches. This brings the bottom of the joist flush with the bottom of the sill, and the top of the joist somewhat above the top of the sill, according to the depth of the joist. The top of a 10-inch joist would come 4 inches above the top of a 6-inch sill, and the joist would rest partly on the masonry wall, thus relieving the connection of a part of the stress due to the weight of the loaded joist. A common but very bad method of framing the joist to the sill is simply to "cut it over" the sill without mortising the latter, as shown in Fig. 147. This does not make a strong con-

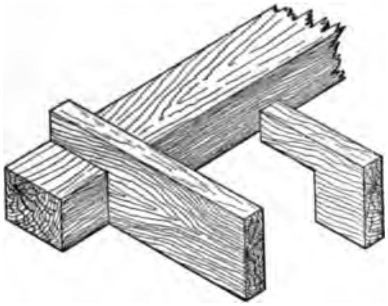


Fig. 147. Bad Method of Framing Joist to Sill

nection even when the joist rests partly on the masonry wall; and if it is not so supported it is almost sure to fail by splitting, as shown in Fig. 148, under a very small loading. In fact, it would be much stronger if the joists were turned upside down. Frequently the joist is cut as shown in Fig. 149, where the tenon is sunk into a mortise cut in the sill, thus bringing the top of the joists flush with the top of the sill; but in this case the bottom of the joists will almost invariably drop below the bottom of the sill and the wall must be cut away to make room for it, as shown in Fig. 140. It is also weak in the same way as is the connection shown in Fig. 148.

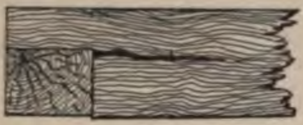


Fig. 148. Crack in Joist Due to Bad Construction

With Girders. The framing of the joists into the girders may be accomplished in several ways, according to the position of the girder. The placing of the girder is quite an important point. The top of the floor, on which rest the sole-pieces of the cross-partitions, must remain always true and level, that is, the outside ends of the joists must be at the same level as the inside ends. Otherwise the doors in the cross-partitions will not fit their frames, and can not be opened or shut and the plastering is almost sure to crack.

Both ends of the joists will sink somewhat, on account of the shrinkage of the timber in seasoning, and the only way to make sure that the shrinkage at the two ends will be the same is to see that there is the same amount of horizontal timber at each end between the top of the floor and the solid masonry. This is because timber shrinks very much across the grain, but almost not at all along the grain. If the joists are framed properly into the sill, so that they are flush on the bottom with the sill, we have at the outer end of the joist a depth of horizontal timber equal to the depth of the joist itself, as shown in Fig. 138; and in order to have the same depth of timber at the inside, the bottom of the joist must be flush with the bottom of the girder, which usually rests on brick piers. Of

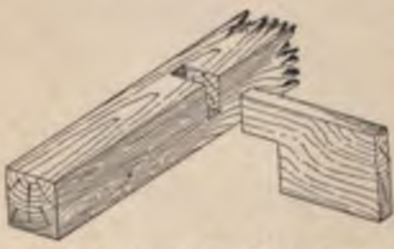


Fig. 149. Another Bad Joist and Sill Construction

course the top of the girder must not in any case come above the top of the floor joists; therefore, in general, the girder must be equal in depth to the floor joists and flush with these joists on top and bottom, as shown in Fig. 150. This method is not always followed, however, in spite of its evident superiority; and the girder is often sunk several inches below the tops of the floor joists, as shown in Fig. 138, or even in some cases very much below, as shown in Fig. 151. Both of these methods cause an unsightly projection below the ceiling of the cellar. Where the joists are brought flush with the girder top and bottom, they may be framed into it with a tenon-and-tusk joint, as are the girders, as shown in Fig. 139, and a hole bored through the tenon to receive a pin to hold the joist in place.

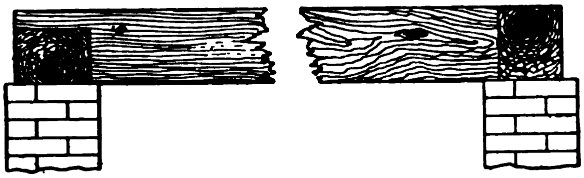


Fig. 150. Superior Floor Joist and Sill Construction

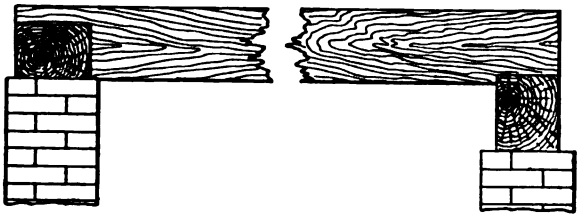


Fig. 151. Joist Sized Down on Girder

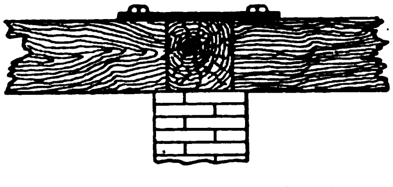


Fig. 152. Fastening Joists by Iron Strap

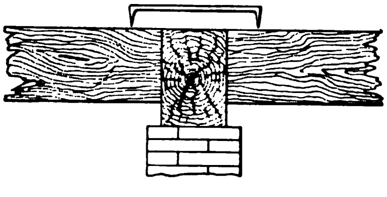


Fig. 153. Fastening Joists by Dog

Other methods of framing tenon-and-tusk joints are shown in Figs. 47, 48, 49, and also a double-tenon joint in Fig. 50, which might be used in this case, although it is much inferior to the tenon-and-tusk joint. Two joists framing into a girder from opposite sides should be fastened strongly together on top either by an iron strap passing over the top of the girder and secured to each joist, as shown in Fig. 152, or by means of a "dog" of round bar iron, which is bent at the ends and sharpened so that it may be driven down into the abutting ends of the joists, as shown in Fig. 153. These bars should be used at every fifth or sixth joist, to form a series of continuous lines across the building from sill to sill.

If the girder is sunk a little below the tops of the joists these may be gained into it in the same way as they are gained into the sill. In this case joists should be arranged as shown in Fig. 154, so that they will not conflict with one another; and the two adjacent joists may be spiked together, thus giving additional stiffness to the floor. If the tenon-and-tusk connection is used, the joists may be arranged exactly opposite each other, provided that the girder is sufficiently wide, but it is always much better to arrange them as shown in Fig. 155, even in this case. The tenon may then be carried clear through the girder and fastened by a dowel as shown. Very rarely a simple double-tenon joint, such as that shown in Fig. 50, might be used, but it is much inferior to either the gaining or the tenon-and-tusk joint.

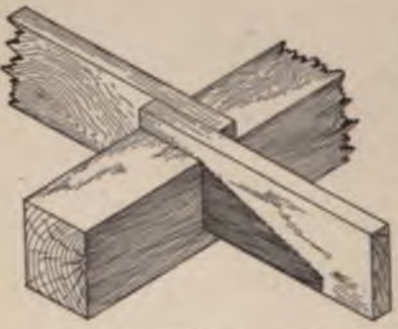


Fig. 154. Joist Gained into Girder

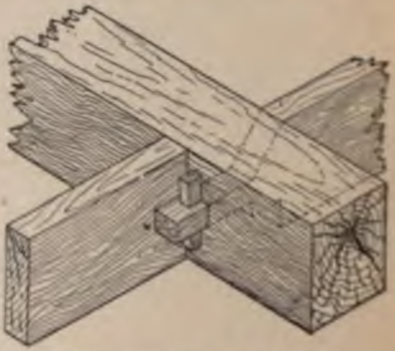


Fig. 155. Joist Fastened to Girder by Tenon Joint and Dowel

If the girder is sunk very much below the tops of the joists, as in Fig. 151, these will usually rest on top of it and be fastened by spikes only, or will be "sized down" upon it about 1 inch, as shown. There is no mortising of the girder in either case. Joists are also thus sized down upon the girts and partition caps, and are notched over the ledger boards as shown in Fig. 105. In cutting the joists for sizing and notching, the measurements should be taken in every case from the top of the joists, since they may not be all of exactly the same depth, and the tops must be all on a level after they are in place. This is really the only reason why the joists should be sized down at all, because otherwise they might simply rest upon the top of the girder, or girt, and be fastened by nailing.

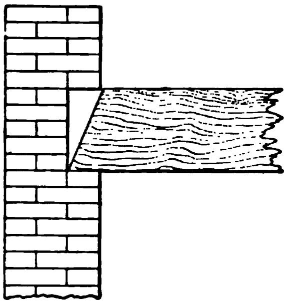


Fig. 156. Joist Supported by Brick Wall

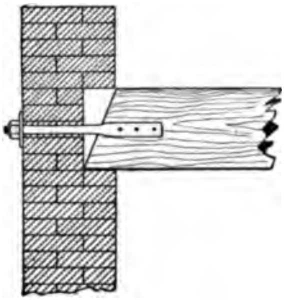


Fig. 157. Anchored Joist

With Brick Wall. When a joist or girder is supported at either end on a brick wall, there will either be a hole left in the wall to receive it, or the wall will be corbeled out to form a seat for the beam. If the beam enters the wall the end should be cut as shown in Fig. 156, so that in case of the failure of the beam from overloading or from fire, it may fall out without injuring the wall. Every fifth or sixth joist is held in place by an anchor, as shown in Fig. 157, of which there are several kinds on the market. Fig. 158 shows the result when a beam which is cut off square on the end, falls out of the wall.

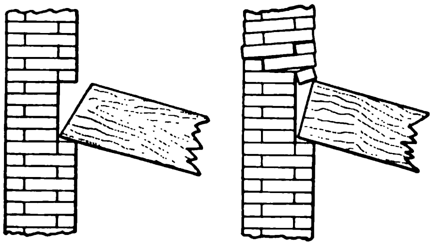


Fig. 158. Effect of Releasing Diagonal- and Square-Ended Joists

There must always be left around the end of a beam which is in the wall, a sufficient space to allow for proper ventilation to prevent dry rot, and the end should always be well painted to keep out the moisture. Patent wall-hangers and box anchors are often used to support the ends of joists in brick buildings, but only in case of heavy floors.

The floor framing in a brick building is the same as that in a building of wood except that there is no girt to receive the ends of the floor boards, so that a joist must be placed close against the inside of the wall all around the building to give a firm nailing for the flooring.

Crowning. In any floor, whether in a wood or brick building, if the span of the floor joists is very considerable so that there is any chance for deflection they must be "crowned" in order to offset the effect of such deflection. The operation called "crowning" consists in shaping the top of each joist to a slight curve, as shown in Fig. 159A, so that it is 1 inch or so higher in the middle than it is at the ends. As the joist sags or deflects, the top becomes level while the convexity will show itself in the bottom, as shown in Fig. 159B. Joists need not be crowned unless the span is quite large and the loads heavy enough to cause a deflection of an inch or more at the center of the joist.

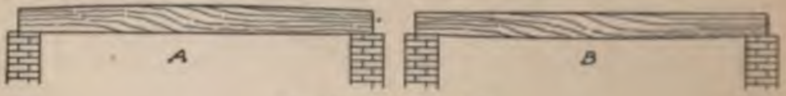


Fig. 159. Crowning Joist

Bridging. Floor frames are "bridged" in much the same way as was described for the walls, and for much the same purpose, namely, to stiffen the floor frame, to prevent unequal deflection of the joists and to enable an overloaded joist to get some assistance from the pieces on either side of it. Bridging is of two kinds, "plank bridging" and "cross bridging," of which the first has already been shown in connection with the partition supports. Plank bridging is not very effective for stiffening the floor, and cross bridging is always preferred. This bridging is somewhat like the diagonal bridging used in the walls, and consists of pieces of scantling, usually 1×3 inches or 2×3 inches in size, cut in diagonally between the floor joists. Each piece is nailed to the top of one joist and to the bottom of the next; and two pieces which cross each other are set close together between the same two joists, forming a sort of St. Andrew's cross, whence we get the name "cross bridging" or "herringbone bridging" as it is sometimes called. The arrangement is shown in Fig. 160, and the bridging should be placed in straight lines at intervals of 8 or 10 feet across the whole length of the floor. Each piece should be well nailed with two eightpenny or tenpenny nails in each end. If this is well done there will be formed a continuous truss across the whole length of the floor which will prevent any overloaded joist from sagging below the others, and which will greatly stiffen the whole floor so as to prevent any vibration. The bridging, however, adds nothing to the strength of the floor.

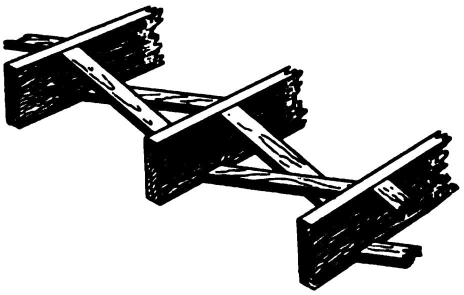


Fig. 160. Cross Bridging between Joists

Porch Floors. A word might be appropriately inserted at this point in regard to floors of piazzas and porches. These may be supported either on brick piers or on wood posts, but preferably on piers, as these are much more durable than posts. If piers are used, a sill, usually 4×6 inches in size, should be laid on the piers all around, and light girders should be inserted between the piers and the wall of the house, in order to divide the floor area into two or three panels. The joists may then be framed parallel to the walls of the house, and the floor boards laid at right angles to these walls. The whole frame should be so constructed that it will pitch outward, away from the house at the rate of 1 inch in 5 or 6 feet, thus bringing

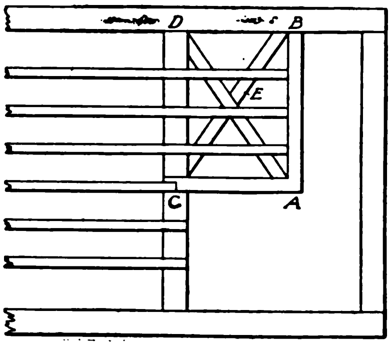


Fig. 161. Construction of Unsupported Corner

the outside edge lower than the inside edge and giving an opportunity for the water to drain off.

Stairs. The stairs are built on frames called "stringers" or "carriages," which may be considered as a part of the floor framing. They consist of pieces of plank 2 to 3 inches thick and 12 or more inches wide, which are cut to form the steps of the stairs and which are then set up in place. There are usually three of these stringers under each flight of stairs, one at each side and a third in the center, and they are fastened at the bottom to the floor and at the top to the joists which form the stair well. This subject is taken up more fully under "Stair Building."

Unsupported Corners. An interesting place in a floor framing plan is where we have a corner without any support beneath it, as at the corner *A* in Fig. 161. This corner must be supported from the three points *B*, *C*, and *D*, and the figure shows how this is accomplished. A piece of timber *E* is placed across from *B* to *C*, and another piece starts from *D* and rests on the piece *B C*, projecting beyond it to the corner *A*. This furnishes a sufficiently strong support for the corner.

CARPENTRY

PART III

THE ROOF

The framing of the roof is one of the most difficult problems with which the carpenter has to deal, not because of the number of complicated details, for these are few, but because of the many different bevels which must be cut in order to allow the rafters to frame into one another properly.

There are many kinds of roofs, and before describing the different varieties it will be well to consider briefly the purpose of the roof and its development from simple forms to those which are more elaborate and perhaps more ornamental. The primary object of a roof in a temperate climate is, of course, to keep out the rain from the interior of the building and at the same time to keep out the cold. The roof must, therefore, be so constructed as to free itself from the falling water as soon as possible, that is, it must be built to shed water and, therefore, it must be sloped or inclined to the horizontal in some way. If it is necessary for the sake of economy or for any other reason to construct the roof practically flat, it must be made more secure against the passage of water than if it is made sloping, and some provision must be made to carry off the water, and to cause it to collect in one or two low places in the roof surface, from which pipes or *down spouts* may be provided to take it away to a safe place outside the building. The roof covering must be of some material through which water will not readily penetrate, such as tin, galvanized iron, lead, or zinc or copper among the metals, or a composition of tar and gravel, if metal is not suitable to the purpose. This would be for a roof which is nearly flat; for a roof which slopes, and will shed the water, thus getting rid of it more quickly, a covering of slates, tile, or wood shingles

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may be employed, as well as tin, copper, or other metals. The slates or shingles would have to be laid in several thicknesses, the number depending upon the steepness of the slope of the roof, and in order to accomplish this they would have to be laid overlapping each other. In order that the water escaping from the roofs may not run down the sides of the building, making unsightly streaks and wetting the windows and doors, it is necessary that the roofs should project somewhat beyond the face of the walls all around. The projecting part of the roof is called the *eaves*.

ROOF CHARACTERISTICS

Styles of Roofs. The different varieties of roofs, from the simple pitch roof to the most complicated combination of hips and valleys, are developments of a few simple forms.

Lean-To Roof. The lean-to roof is the most simple of them all, and is usually employed for small sheds, piazzas, porches, ells, and in many other situations where appearance is not a matter of great moment, and where the essential thing is to obtain the shelter as cheaply and as easily as possible. The lean-to roof is shown in Fig. 162. It consists of a plain surface, one end or one side of which is raised to a higher level than the other side or end, and supported in this position by means of walls or by means of posts at the four corners. The position in which the surface is supported enables the rain water to drain freely from it, and thus it fulfills the requirements of a roof so long as it remains water-tight.

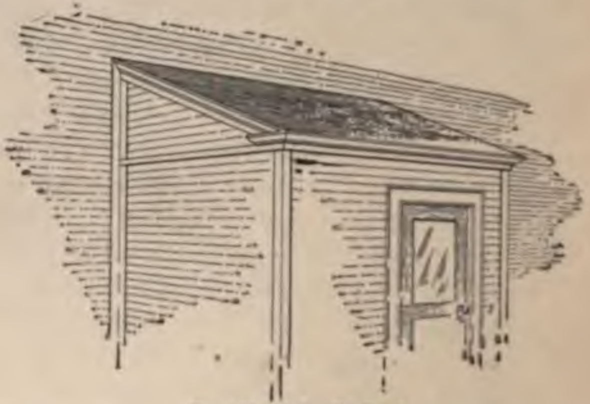
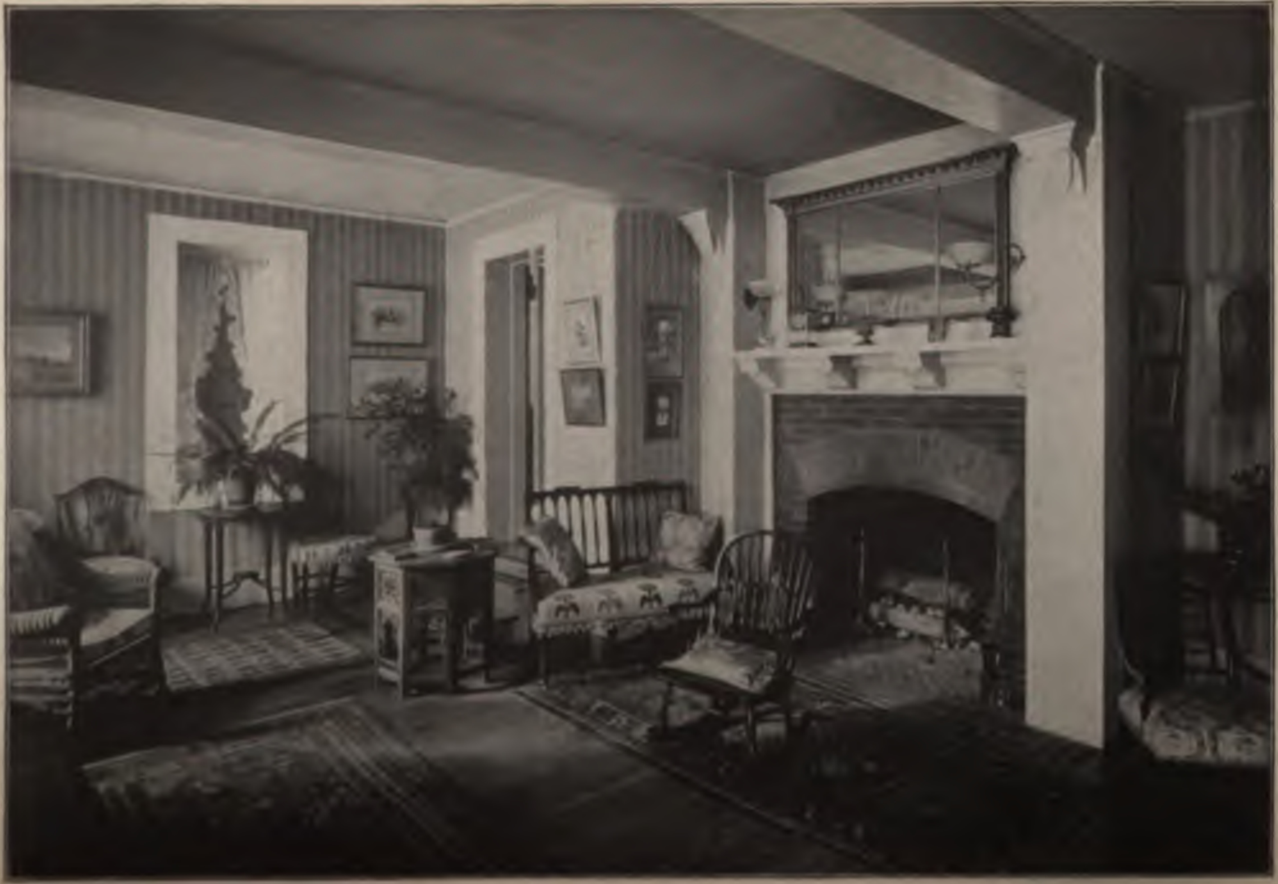
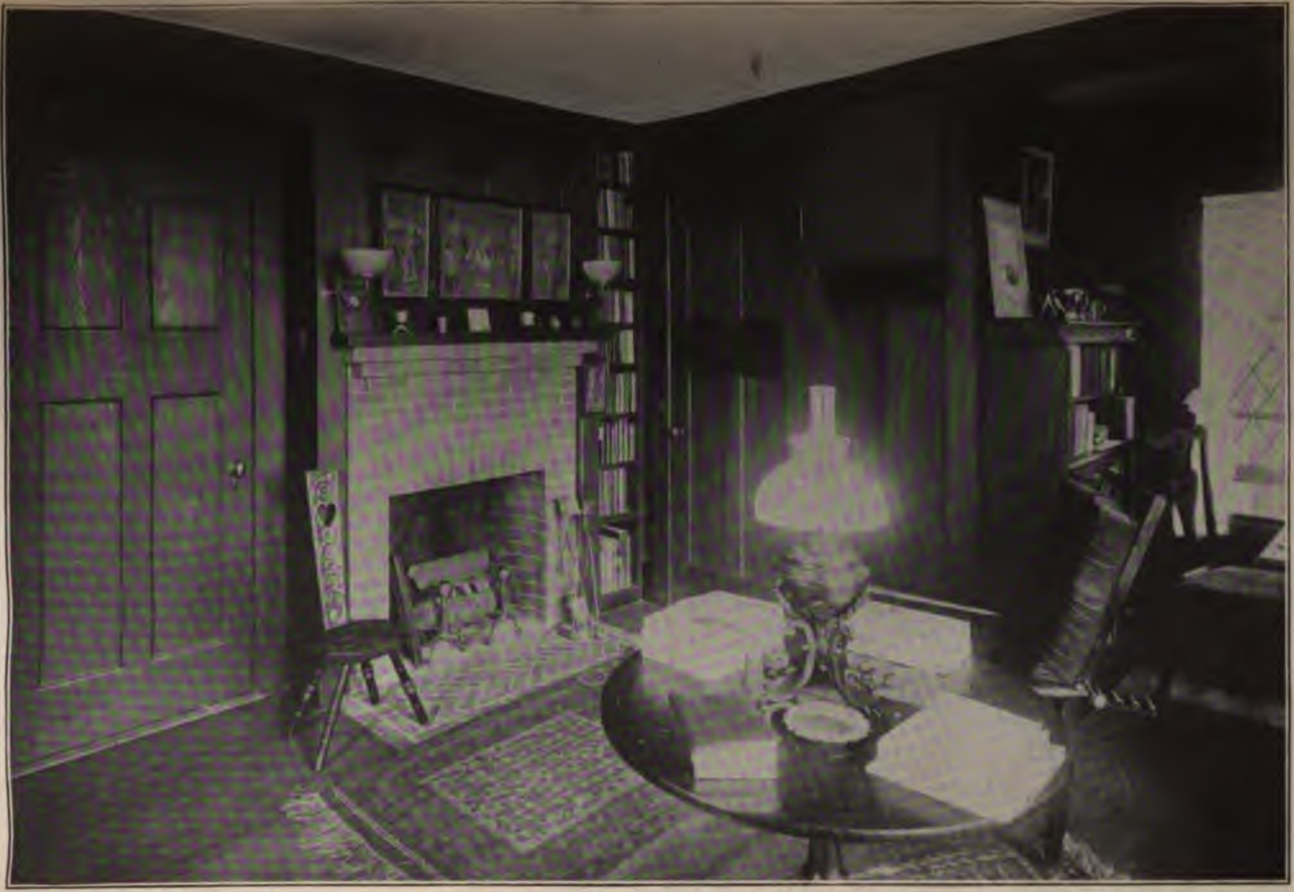


Fig. 162. Lean-To Roof



LIVING ROOM IN HOUSE FOR MR. C. M. THOMPSON, CAMBRIDGE, MASS.



LIBRARY IN HOUSE FOR MR. C. M. THOMPSON, CAMBRIDGE, MASS.
Cram, Goodhue & Ferguson, Architects, Boston and New York.

Pitch or Gable Roof. Next to the simple lean-to roof with a single sloping surface comes the ordinary pitch or gable roof, which has two sloping surfaces one on each side of the center line of the building, coming together at the ridge in the middle. This form of roof, which is shown in Fig. 163, is very common and is also quite simple in design, and economical in construction, so that it has been very popular indeed for all classes of buildings except very large structures and city buildings. The slope of the roof, that is, its "pitch" or its inclination to the horizontal, may be varied to an infinite extent, from a very flat slope to a very steep one, and these variations have been made in different countries and in different climates to suit either the taste of the designers or the practical requirements of the climate. The roof may be used in combination with roofs of other kinds and, indeed, it is usually used in this way,

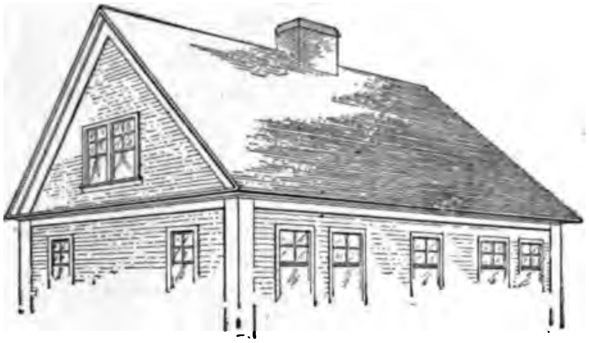


Fig. 163. Pitch or Gable Roof

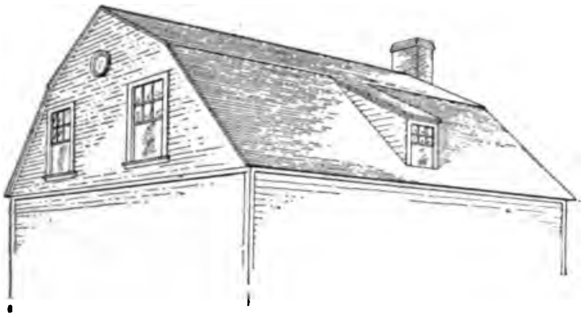


Fig. 164. Gambrel Roof

so much so that, although the simple gable roof is the base of almost all the roofs of ordinary structures, it is sometimes hard to distinguish it from among the other roofs which have been added as additions to it.

Gambrel Roof. The gambrel roof is a variation of the simple pitch or gable roof and was probably developed from it to meet a new condition, namely, the necessity for more space in the portion of the building immediately under the roof surface. This form of roof has a sort of gable at each end of the building, but the gable is not triangular in shape, as is shown in Fig. 164. It will be seen that the roof surface has been broken near the middle on both sides of the building and that the portion below the break has been made steeper, and the portion above the break flatter than would be the case in a simple roof surface for a building of the same size with a gable roof. This arrangement allows of considerably more space and much greater head room in the attic. The position of the break in the roof surface may be varied to suit the taste of the designer, and the slopes of both the upper and the lower parts of the roof may be arranged as desired. Gambrel roofs may be seen on many old houses built in the Colonial days, and they have lately come again into favor for the roofs of cottages and small suburban or country houses.

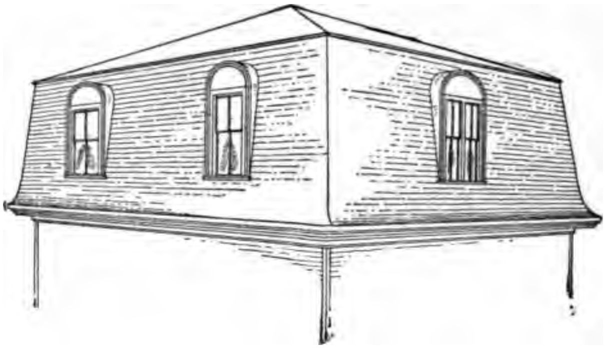


Fig. 165. Mansard Roof

Mansard Roof. The mansard roof, called by the name of the architect who introduced it, is like the gable roof except that it slopes very steeply from each wall toward the center, instead of from two opposite walls only, and it has a nearly flat *deck* on top. This form of roof gives better rooms in the attic space than does either of the two forms already described. It was at one time very popular for large suburban and city houses, but it is now seldom employed. The mansard roof is shown in Fig. 165. It bears a close relation to the so-called *hip* roof.

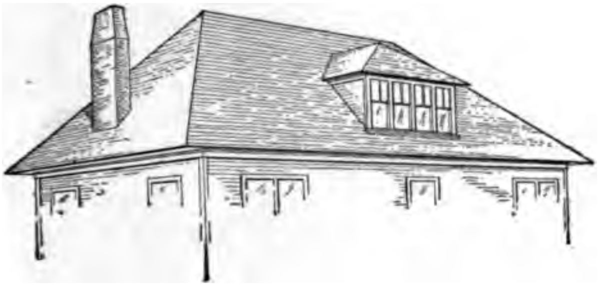


Fig. 166. Hip Roof with Ridge

Hip Roof. The hip roof also slopes from all four walls toward the center, but not so steeply as does the mansard roof. It is usually brought to a point or a ridge at the top, as in Fig. 166, but sometimes it is finished with a small flat deck, as in Fig. 167. The hip roof as a rule allows of very little useful space in the attic, and if this type of roof is employed it is usually done with the idea of sacrificing the attic space and doing without the rooms under the roof for the sake of the exterior appearance.

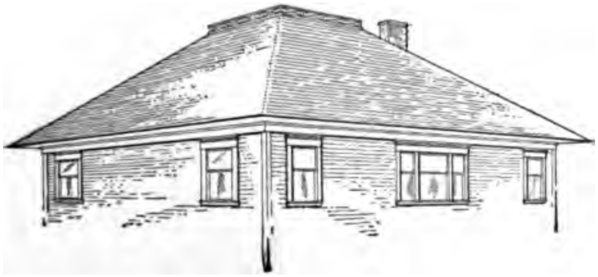


Fig. 167. Hip Roof with Deck

Valley Roof. In Fig. 168 is shown a very simple form of what is known as a valley roof. It is a combination of two simple pitch roofs which intersect each other at right angles. In the figure both ridges are shown at the same height, but they are not always built in this way. Either ridge may rise above the other, and the two roofs may have the same pitch or different pitches. If the ridge of

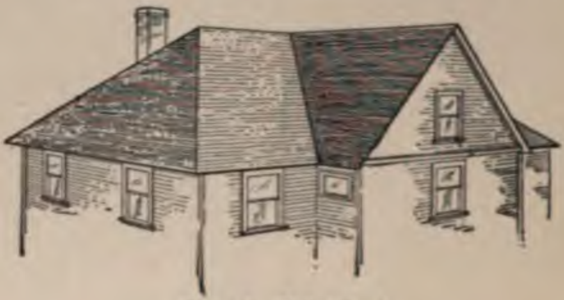


Fig. 168. Valley Roof

the secondary roof rises above the ridge of the main roof, the end which projects above the main ridge is usually finished with a small gable *a*, or a small hip *b*, as shown in Fig. 169. This arrangement does not make a pleasing appearance, however, and should be avoided if possible. Almost all roofs are hip and valley roofs, as it is very seldom that a building of any considerable size can be covered with a simple roof of any of the forms described above. There

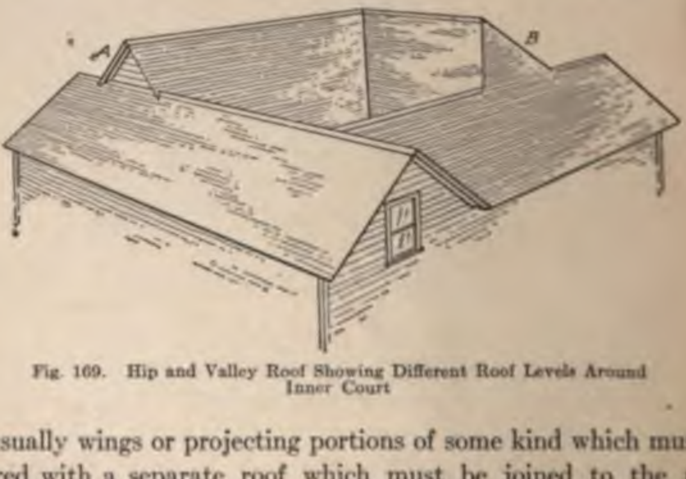


Fig. 169. Hip and Valley Roof Showing Different Roof Levels Around Inner Court

are usually wings or projecting portions of some kind which must be covered with a separate roof which must be joined to the main body of the roof with valleys, and it is these valleys which are the cause of most of the leaky roofs, as a large quantity of water collects in them and it is no easy matter to make them waterproof.

Rafters. In all roofs the pieces which make up the main body of the framework are called the rafters. They are for the roof what the joists are for the floor, and what the studs are for the wall. The rafters are inclined members, spaced from 16 to 24 inches apart on centers, which rest at the bottom on the plate, and are fastened at the top in various ways, according to the form of the roof. The plate, therefore, forms the connecting link between the wall and the roof and is really a part of both of them. The size of the rafters varies, depending upon their length and the distances at which they are spaced. It is sometimes allowable to use them as small as 2×4 inches, but this should be done only for the lightest work. The size of the rafters for an ordinary dwelling house is usually 2×8 inches. In larger buildings, such as school houses, it may be found necessary to use rafters as large as 2×10 inches, when they are of a considerable length.

The material usually employed for rafters is the same as that used for the joists and for the studding. This is generally spruce in the eastern states and yellow pine in the Mississippi Basin, but may be hemlock in very cheap work. The size and spacing of the rafters vary to some extent with the location of the building, as in the northern part of the country the roof is called upon to carry a considerable weight of snow and ice, while in the south there is little or no snow and the roof is not called upon to carry so much weight. If snow freezes and packs on the roof it may weigh as much as twenty-five or thirty pounds per square foot of roof surface. The wind pressure must also be considered, as well as the weight of the material composing the roof itself.

The connection of the rafters to the wall is the same in all the types of roofs described above. They are not framed into the plate but are simply spiked to it, being cut at the bottom so as to rest on top of it. Usually they extend out for a considerable distance beyond the wall to form the eaves, as shown in Fig. 170, and they are then cut over the plate and allowed to continue beyond it. The usual length for the eaves is about 1 foot, but it may vary to suit the taste of the designer of the building. Sometimes the rafter itself is not extended beyond the plate, but is cut off just as though it was not intended that it should continue beyond the wall line, and a separate piece called a "false rafter" is nailed against it alongside to form the projection for the eaves, as shown in Fig. 171. This piece does not always continue in the same line with the real rafter, but may, and usually does, make an angle with it, as shown in the figure, so as to give a break in the roof line near the line of the eaves.

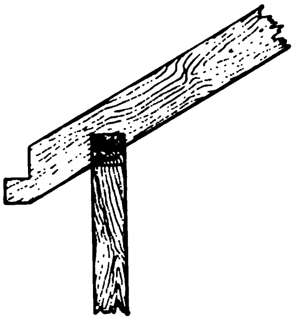


Fig. 170. Rafter Extended to Form the Eaves

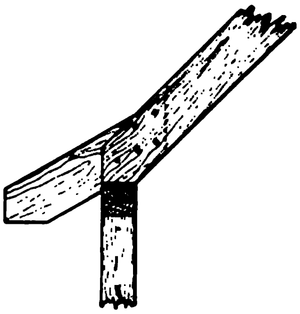


Fig. 171. False Rafter

It is sometimes desired to form a concealed gutter around the eaves, and in order to do this the joists are allowed to extend 10 or 12 inches and on the ends of these a 2×4 is laid flat and nailed, and the rafters rest on this piece. The scantling is nailed directly above the plate and the gutter is run in notches cut in the

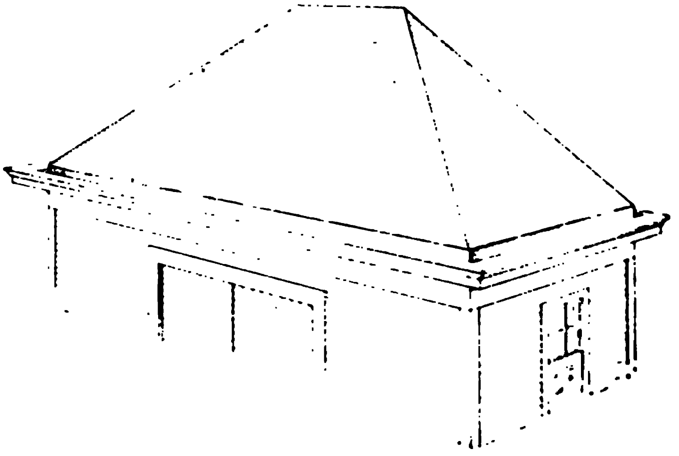


Fig. 172. Roof Showing Concealed Gutter

overhanging joists which also support the cornice. The general appearance is shown in Fig. 172 and the details of the construction in Fig. 173.

There are four different kinds of rafters used in framing roofs, all of which may sometimes be found in a single roof frame, if the roof is of complicated design, while ordinary roofs may be framed with only the more simple forms of rafters. In Fig. 174 is shown in plan the framing for a roof in which all four kinds of rafters are to be found. *A A A* are the common rafters, which extend from the plate to the ridge and which are not connected with or crossed by any of the other rafters. *B B B* are *jack* rafters, which are shorter than the common rafters and which do not extend from the plate to the ridge, but are connected at one end to a *hip* or *valley* rafter. *C C* are the valley rafters, which are needed at every corner between the main building and an ell or other projection, while the hip rafters *D D* are found at the outside corners. At the points where the valley rafters are situated there are troughs or valleys formed by the roof surfaces—as these pitch downward on both sides toward the valley rafter—while at the outside corners, where the hip rafters are found, the roof surfaces pitch upward on each side to the hip rafter. This may be seen and perhaps better understood by looking at any hip and valley roof as actually constructed, and as this type of roof is very common there will be no lack of examples.

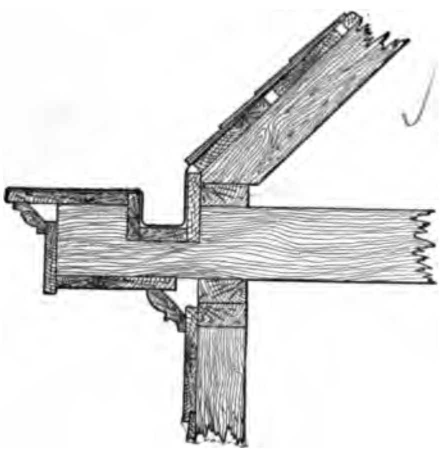


Fig. 173. Construction of Concealed Gutter of Fig. 172

Pitch of Roof. The *pitch* of a roof is the term used to indicate the slope of the sides of the roof surface or the inclination of these sides with respect to a horizontal plane or a surface absolutely flat and parallel to the horizon. Evidently the pitch of any roof may vary to an almost infinite extent. It may be absolutely flat or it may be practically vertical, or it may be inclined at any angle between these two limits. Unfortunately there are several systems in use for indicating the pitch or the amount of the angle of the slope, so that there is likely to be some misunderstanding about it. Usually, however, some one system is in use in any one section of the country and there is a general understanding that this is the system intended when speaking of the pitch of a roof. The most simple way of indicating the pitch and at the same time the most accurate way, is to give the angle which the roof surface makes with a horizontal plane Thus the pitch of the roof may be thirty degrees, or forty-five degrees or sixty degrees. This system is much in use among civil engineers, by whom it is favored on account of its accuracy and the small probability of its being misunderstood, but it is not much in use among carpenters and architects, who generally prefer to use some other system.

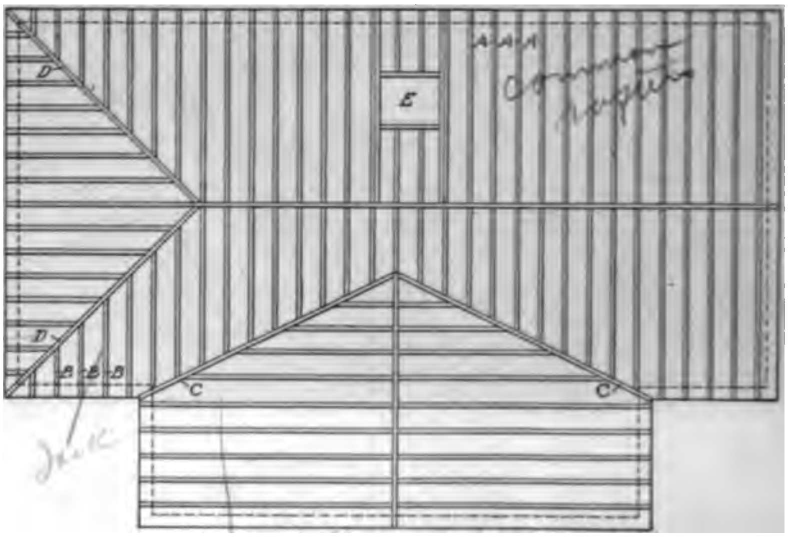


Fig. 174. Plan of Roof Framing Showing Use of Four Kinds of Rafters

Another method of indicating the slope of the roof surfaces is to take the rise of the roof at the center of the span, or the vertical distance from the top of the plate to the under side of the rafters at the center of the span, and to divide this distance by the span itself or the distance between the inside edges of two rafters which come opposite to each other in the roof frame, at the point where they intersect the top surface of the plate. The fraction thus obtained is used to express the degree of slope of the roof, or the angle that the roof surface makes with the horizontal plane, in the following way: If the span of the roof between the edges of the rafters at the level of the top of the plate is 20 feet and the rise of the roof at the center, measured vertically from the top of the plate to the under side of the rafters, is 10 feet, then the roof is of *half pitch,* since the fraction obtained by dividing the rise of the roof by the span of the roof is one over two or one half. The angle which this roof surface makes with the horizontal plane is forty-five degrees, since the rise at the center is equal to half the span, and the rise of the sloping rafter is equal to its *run* or its projection on the horizontal plane. This slope is also called a *square slope* or a *square pitch* for the reason that the rise of the rafter is equal to its run. In this roof also it will be seen that the rafter rises a distance of 12 inches for each foot of run, counting the rise always from the level of the top of the plate and the run from the point where the under side of the rafter intersects the top of the plate. Thus at the center of the roof the run is 10 feet and the rise is also 10 feet. If this same roof were one of *full pitch,* the rise at the center of the span would be 20 feet, equal to the span itself, and there would be 2 feet of rise for each foot of run. This would make a very steep roof, in fact it is very seldom so steep a roof is used in ordinary work. A two-thirds pitch would be a little less steep than the full pitch, between the full pitch and the half pitch, and this roof would have a rise of 16 inches for each foot of run, so that if the span were 20 feet, as in the case of the other roofs just mentioned, the rise at the center of the span would be 160 inches or 13 feet and 4 inches. The reason why this pitch is called a *two-thirds pitch* is that in the case of a full pitch roof the rise for each foot of run is 24 inches, in this case the rise for each foot of run is 16 inches, and 16 inches is just two-thirds of 24 inches. Also the rise at the center of the span, 13 feet and 4 inches, is just two-thirds of the span, which is 20 feet. Whenever it is desired to give a roof a steeper pitch than the half pitch, the two-thirds pitch is generally employed.

If the roof is one of *one-third pitch,* the rise of the rafter for each foot of run will be one-third of the 24 inches which are required to make a full pitch, one-third of this being 8 inches. Thus a one-third pitch roof has a rise of 8 inches for each foot of run, and the rise at the center of the span is one-third of the entire span. If the span of the roof is 20 feet, the rise at the center of the span will be 6 feet and 8 inches, or just one-half as much as in the case of the roof of the same span and with a two-thirds pitch.

If the roof has a "one-quarter pitch," this means that the rise of the rafter for each foot of run is one-quarter of 24 inches, which is 6 inches, and that the rise of the roof at the center of the span is one-quarter of the entire span. If the roof has a span of 20 feet, this will make the rise in the case of a one-quarter pitch equal to 5 feet.

The pitches mentioned above are the most common pitches and those most generally used, though, of course, any pitch may be used as desired. The two-thirds pitch corresponds to an angle with the horizontal of about fifty-three degrees, and the one-half pitch corresponds exactly with an angle of forty-five degrees. The one-third pitch corresponds to an angle of thirty-three and three-quarters degrees and the one-quarter pitch corresponds with an angle twenty-six and one-half degrees. From this it will be seen that the names of the pitches, *one-third*, *one-half*, and *one-quarter*, do not express the relation of the angles which the various slopes make with the horizontal to the angle made by the roof of *full* pitch.

There are several factors which enter into the problem of determining the most suitable pitch to give a roof, and they must be carefully considered before arriving at a decision. In the first place there is to be considered the appearance of the finished roof when the building is completed. In this connection it may be said that personal preference and individual taste on the part of the designer are the determining factors, and that no hard and fast rules can be laid down. Another thing which must be thought of is the relative cost of the different slopes or pitches, as this is often of great importance and, in the case of a large number of buildings, would make considerable difference in cost. It may be said that in general a roof with a comparatively low pitch, say about thirty degrees, corresponding to a rise of approximately 6⅞ inches per foot of run, is the most economical so far as the roof framing alone is concerned. Of course such a roof gives no accommodation in the attic portion of the building. Consideration must also be given to the question of the climate in which the proposed building is to be erected, as this will have a very decided influence upon the decision in regard to the most suitable pitch for the roof. In cold northern climates where the snowfall is great, it is best to have a roof with a steep pitch, so that it will shed the snow and rain, or melted snow as quickly and as thoroughly as is possible. In a warm southern climate where there is no snow and where the rain fall is not large, a roof of smaller pitch may safely be used and will be more economical of construction. The character of the material to be used for covering the roof surfaces must also be remembered in determining the pitch, since if this roof covering is very impervious to water the roof may be given a lower pitch than if the roof covering is more easily penetrated by rain and snow. In general it may be said that roofs covered with slates may be safely given a pitch of from 5 to 5½ inches to the foot run, while a roof covered with shingles must not be flatter than thirty degrees or nearly 7 inches to the foot run. Flat roofs should be covered with some preparation of tar and gravel, or with metal, tin, copper, galvanized iron, or zinc. Any roof which has a rise of less than 3 inches to the foot may be considered to be flat.

ROOF FRAME

Layout of Roof Plan. The laying out of the roof plan for a building is a problem which requires some little thought and skill and it may be well to give a little space to a consideration of the best way in which to approach this problem. Suppose that we have a frame building whose general outline in plan is as shown in Fig. 175, and on which we wish to plan a hip and valley roof. There are, we will say, two projections or wings on the front of the building, at *A A*, another wing on the right-hand side of the building at *B*, and another wing on the back of the building at *C*.

The first thing to do is to draw the rectangle *A B C D*, in Fig. 176, enclosing the main portion of the building, and leaving out the wings or projections. From each corner of the rectangle *A B C D*, may be drawn a line at forty-five degrees, with the side of the rectangle, each pair of which will meet at the points *R R*, and these points *R R* may be connected by a line parallel to the long sides of the rectangle. This is a plan of a simple hip roof covering the main portion of the building, *E* being the ridge and *G G G G* being the hip lines. The projecting portions or wings are, however, not yet

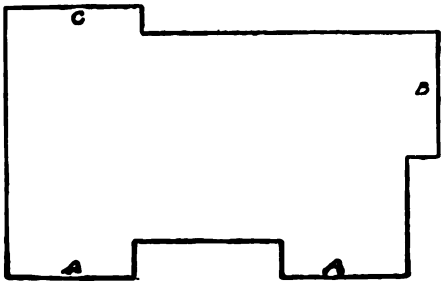


Fig. 175. Ground Plan of Building on Which Rafter Must Be Placed

covered and in order to take care of them some further planning is necessary. Let us consider the two wings on the front of the building, marked *A A*, in Fig. 175. We will decide to cover these with a simple gable roof and for this the first step is to draw in the ridges. These ridges will, of course, come exactly in the center of the wings and will be shown on the plan by a line in the center of the plan of the wings, perpendicular to the line of the front. These lines should be drawn in as shown in Fig. 177, where they are marked *E E*. The lines *E E* intersect the hip lines marked *G G*, in Fig. 176, at a point about half way between the corners *D* and *C*, and the peaks *R R*. In order to look well the slope or pitch of the sides of the pitch roof which covers the wings *A A*, must be the same as the slope or pitch of the end of the hip roof shown in Fig. 176 and there marked *S S*,

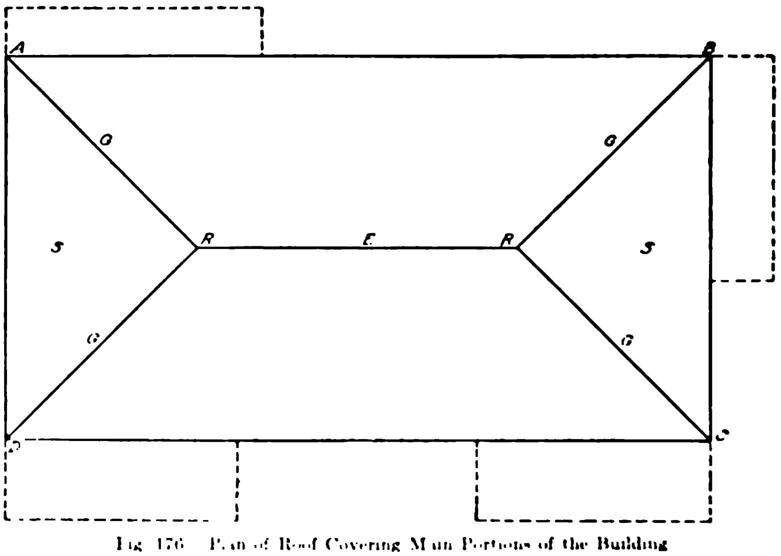


Fig. 176. Plan of Roof Covering Main Portions of the Building

and thus the roof of the wing *A* will on that side become a part of the roof over the main portion of the building, and the lower portion of the hip line *G* may be erased, leaving only the upper portion showing as a hip, as indicated in Fig. 177. The other side of the pitch roof over the wing *A* will, however, not correspond with any slope in the roof over the main portion of the building and must intersect it in some line. Since the ridge *E* is at the top of this roof surface and the wall line of the wing *A* is at the bottom of the roof surface, a line drawn from the corner in which the wall line of the wing intersects the wall line of the main portion of the building, to the point in which the ridge line intersects the hip line of the main roof, will be the line of intersection of the two roofs. This line is shown in Fig. 177, where it is marked *F*. The line *F* in the plan, Fig. 177, will represent a valley. Thus we have the two wings, *A A*, Fig. 175, completely roofed over, and the small roofs connected to the large main roof.

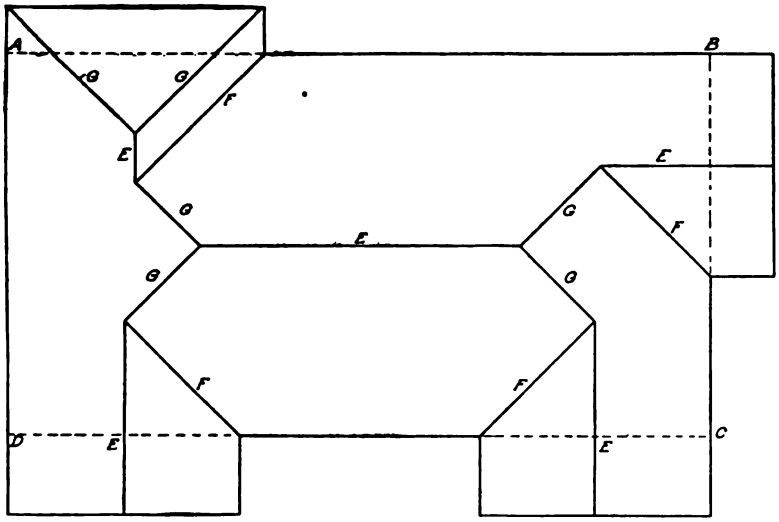


Fig. 177. Added Development of Roof Plan Covering Wings A, B, and C of Fig. 175

Suppose that we wish to cover the wing on the right-hand side of the building also with a simple gable roof. This wing is marked *B* in Fig. 175. We proceed in the same way as explained for the wings *A A*, drawing the ridge line *E*, in Fig. 177, until it intersects the hip line of the main roof *G* and then drawing the valley line *F*. The slope on the back side of the roof over the wing *B* should have the same slope as the back side of the main hip roof and, therefore, the lower part of the hip line *G*, starting at the point *B*, can be erased, leaving only the three lines, *E*, *F*, and *G*, shown in Fig. 177. Thus the wing *B* is completely roofed over and shown in plan. The line *F* in this case also represents a valley. Suppose that we wish to cover the wing on the back of the building, marked *C* in Fig. 175, with a hip roof instead of a gable roof.

We will start at the outside corners, and from these points draw lines *G G* in Fig. 177 at forty-five degrees with the front and side wall lines of the wing, until they meet. The lines must meet exactly in the center of the wing between the two side wall lines, and from this point a line should be drawn at right angles to the front wall line of the wing, but away from this wall line instead of towards it. This line is marked *E* in Fig. 177. It will intersect the hip line *G* of the main roof and from this point of intersection a line *F* should be drawn at forty-five degrees, which will meet the side wall line of the wing in the point in which this side wall line meets the main wall of the building. One slope of the roof over the wing *C*, Fig. 175, will be the same as the slope of the end of the main hip roof, and so the lower part of the line *G*, starting at the point *A*, may be erased and the upper part only left to show as a hip line. The line *F* in this case also will be a valley line. Thus the wing *C*, Fig. 175, will be completely roofed over and shown on the plan. Our roof plan is now complete in outline, all the lines marked *E* being ridges, all the lines marked *G* being hip lines, and all the lines marked *F* being valley lines. The same method of procedure may be followed out in the case of any roof plan, and the final complete plan obtained by successive steps as explained above. The first step is always to lay out the roof over the main portion of the building and then to proceed with the roofing of the projecting portions or wings.

Ridge. In the lean-to roof the rafters rest at the top against the wall of the building of which the ell, or porch, is a part; and the work of framing the roof consists simply in setting them up and securing them in place with spikes or nails. The pitch roof, however, is formed on the principle that two pieces which are inclined against each other will hold each other up, and so the rafters must rest against each other at the top in pairs, as shown in Fig. 178. It is customary to insert between the rafters, at the top, a piece of board about 1 inch in thickness and deep enough to receive the whole depth of the rafter, as shown at *A* in Fig. 179. This piece of board is called the *ridge* or the *ridge pole* and extends the whole length of the roof. It serves to keep the rafters from falling sideways, and keeps the roof frame in place until the roof boarding is on. It is sometimes extended above the rafters, and forms a center for some form of metal finish for the ridge, as shown in Fig. 180.

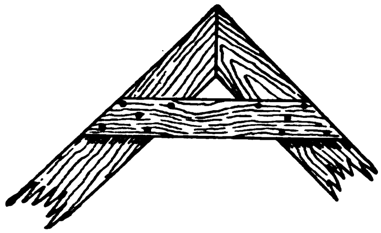


Fig. 178. Construction of Ridge

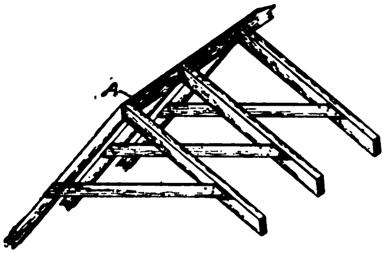


Fig. 179. Placing of Ridge Pole between Abutting Ends of Rafters

Interior Supports. In small roofs which have to cover only narrow buildings and in which the length of the rafters is short, there is no necessity for any interior support, and when the rafters have been cut to the correct length, set up against the ridge, and secured in place, the roof framing is complete. In long spans, however, the roof would sag in the middle if it were not strengthened in some way, so it is customary to support long rafters as near the

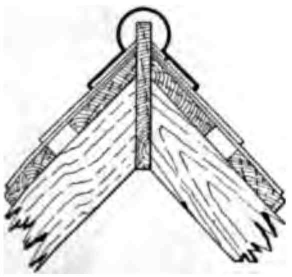


Fig. 180. Ridge Pole Extended above Roof

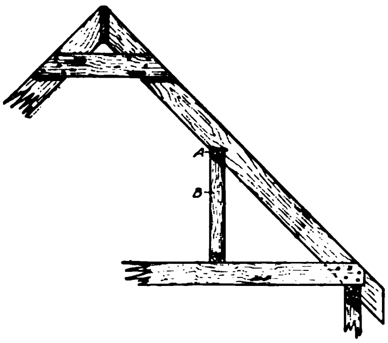


Fig. 181. System of Interior Supports for Rafters

center as possible. This support may be formed by placing a piece of studding under each rafter, somewhere between the plate and the ridge, and if this is done very much lighter rafters can be used than would otherwise be considered safe. It is claimed by some that it is cheaper to do this than to use the heavy rafters. A more common method is to use fewer upright pieces and to place a horizontal piece *A* on the top of them, running the whole length of the building and supporting each rafter. This is shown in Fig. 181. An upright piece *B* should be placed under every sixth or seventh rafter in order to give the necessary stiffness to the whole construction. For the uprights, pieces of ordinary studding 2×4 inches or 2×3 inches in size may be used. When there is to be a finished attic in the building, these upright studs may be made to form the side walls of the attic rooms, and are then spaced about 16 inches on centers to receive the laths. Such walls are called dwarf walls.

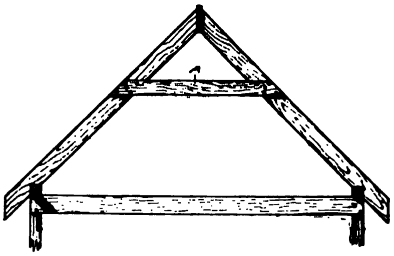


Fig. 182. Collar or Tie Beams as Interior Support for Rafters

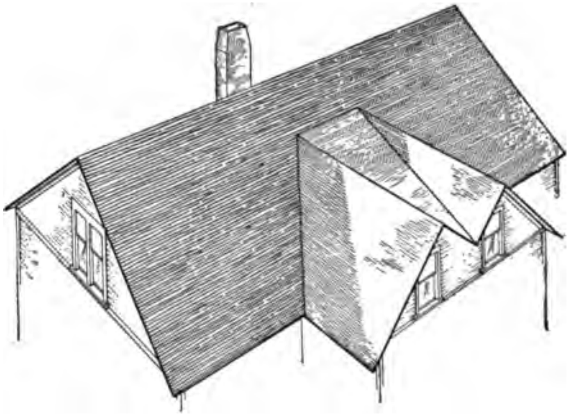
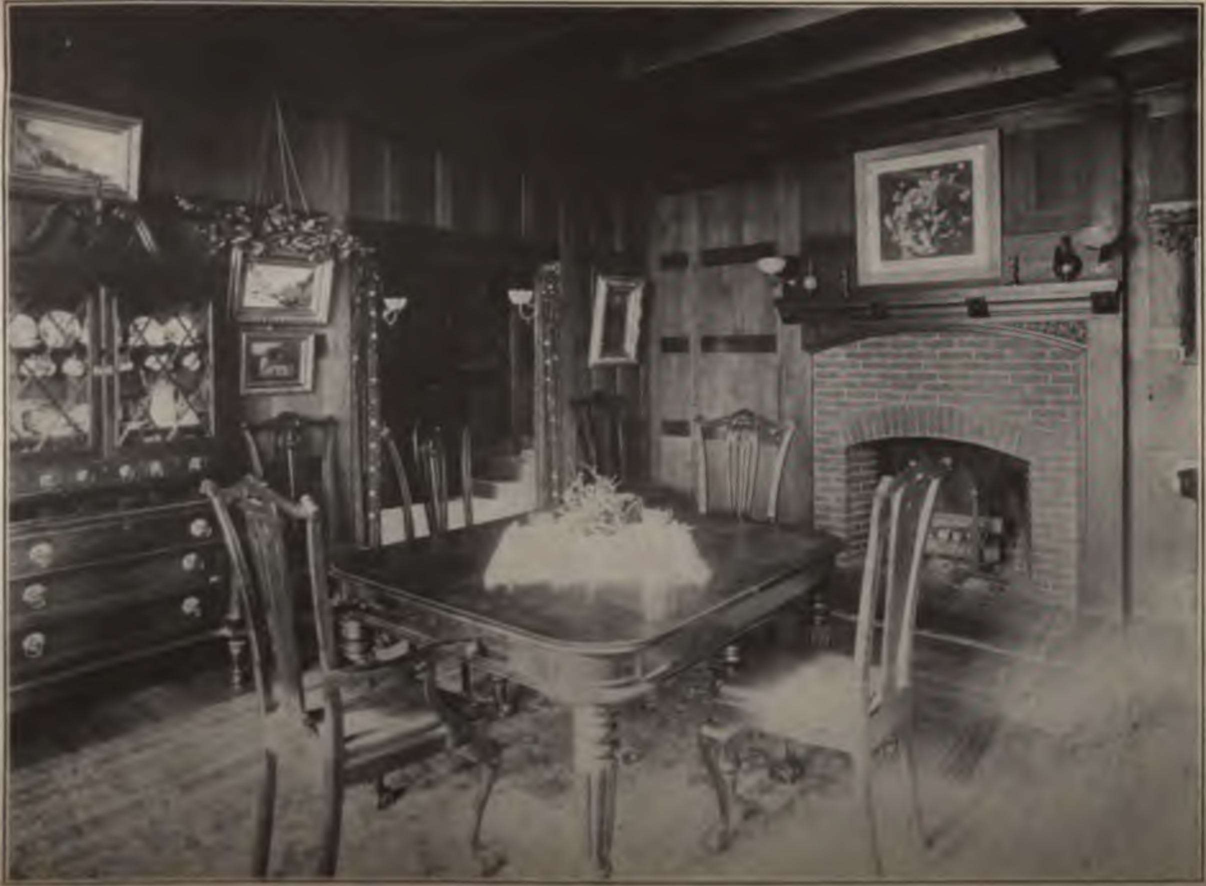


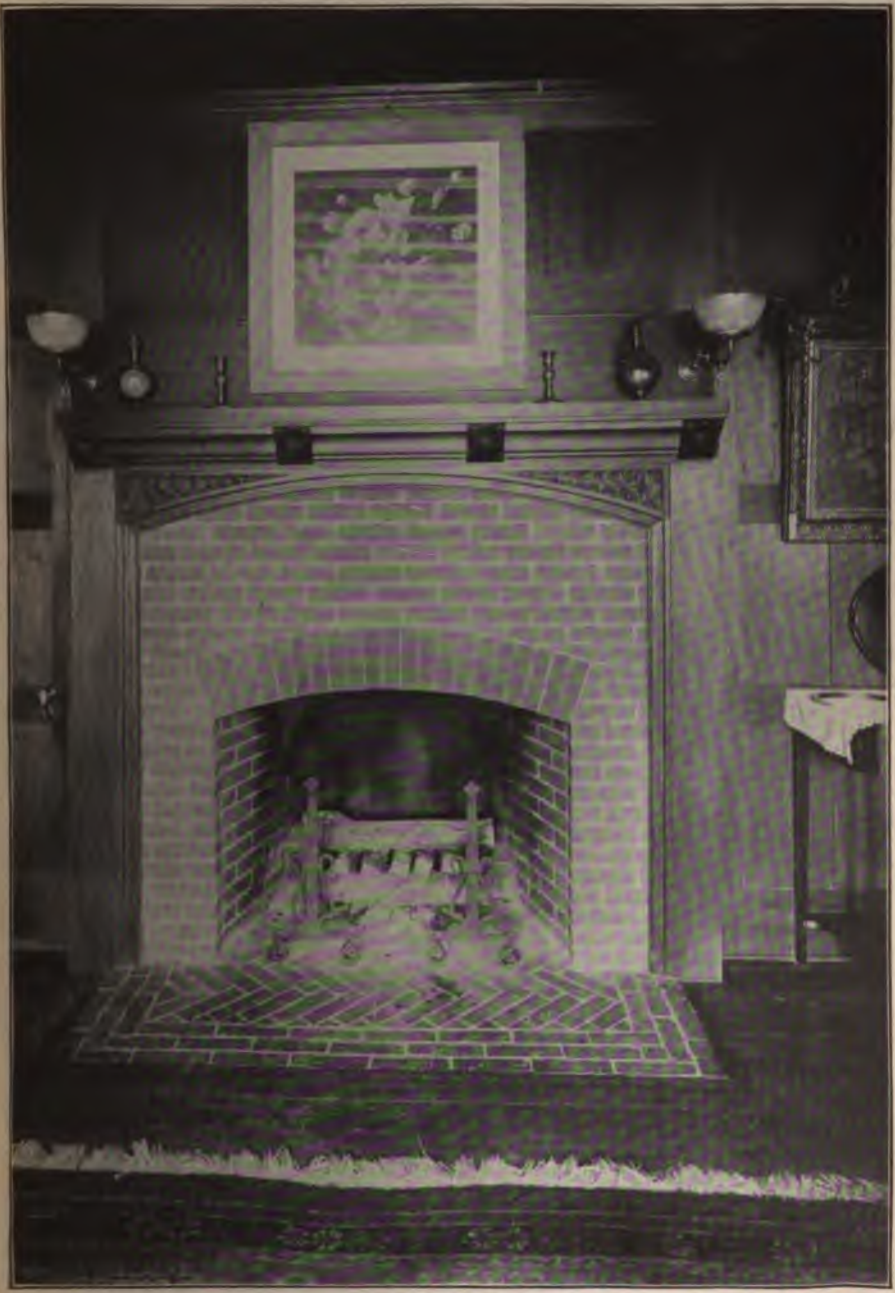
Fig. 183. Example of Double Gable Roof

Another form of interior support is the collar beam or tie beam. This is a piece of timber which extends between the rafters on opposite



DINING ROOM IN HOUSE FOR MR. C. M. THOMPSON, CAMBRIDGE, MASS.

Cram, Goodhue & Ferguson, Architects, Boston and New York



FIREPLACE IN DINING ROOM OF HOUSE FOR MR. C. M. THOMPSON, CAMBRIDGE, MASS.
Cram, Goodhue & Ferguson, Architects, Boston and New York.

sides of the roof and ties them together, as shown at *A* in Fig. 182. It may be a piece of board about 1 inch thick and 8 or 10 inches wide, which is nailed onto the side of the rafter at each end. It is placed as near the center of the rafter as may be practicable, and in the case where a finished attic is required it forms the support for the ceiling. For this reason it must be at a considerable height from the attic floor, and can not always be placed very near the center of the rafter. The important point is to see that it is well nailed at each end.

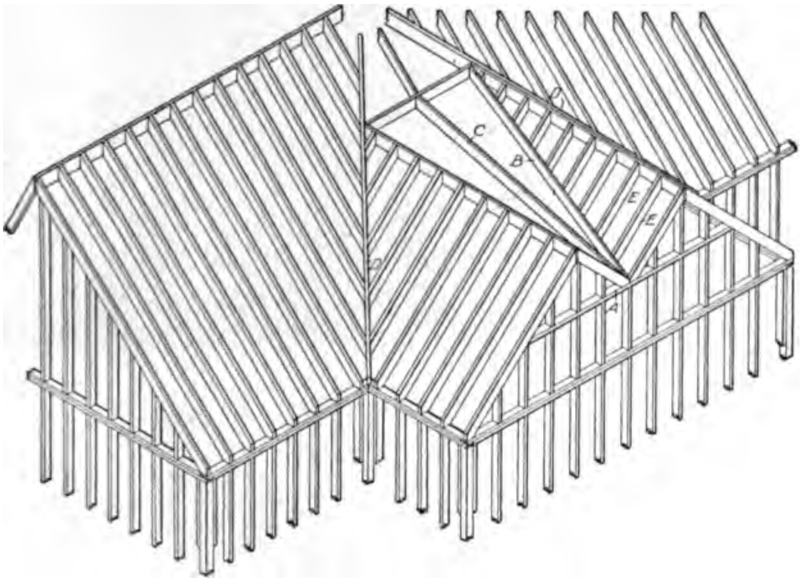


Fig. 184. Rafter and Wall Framing for Double Gable Roof

Double Gable Roof. A very interesting form of gable roof is that in which there is a double gable with a valley between, which forms the roof of an ell when the main roof is a simple pitch roof. This form of roof is shown in Fig. 183. Fig. 184 shows how such a roof may be framed. The piece *A* is placed in the wall and supported by the studding so as to serve as a plate to receive the ends of the valley rafters *B*. These, together with the piece *C*, form the framing for the shallow valley between the two gables. The valley rafters on the outside, marked *D* in the figure, are similar to those used in the case of a single gable. The pieces *E E* are jack rafters and are very short. This form of roof is not common, but in some places it gives a good effect.

Gambrel Roof. A gambrel roof is framed in very much the same way as is a pitch roof or a hip roof. The slope of the roof, however, is broken at a point between the plate and the ridge. The part of the roof above this break makes an angle with the horizontal plane of less than forty-five degrees usually, while the portion below the break makes an angle with the horizontal plane greater than forty-five degrees. This is shown in Fig. 185.

The lower slope may almost be considered a part of the wall, and at the point where the slope changes there is a secondary plate from which the upper slope starts, as shown at *A* in Fig. 185. The secondary plate may be utilized as a support for the ends of the ceiling joists *B*, which should also be securely spiked to the rafters, as shown in the figure. The rafters *C* forming the upper slope, must be cut over the plate *A*, and firmly spiked to it, while at the top they rest against a ridge board *D*. The rafters *E*, forming the lower slope, are cut out at the top so as to form a seat for the plate *A*, and must be very securely fastened at the bottom to the main wall plate *F*. It is an excellent plan to have the floor joists *G* spiked to the lower rafters, so as to act like tie beams across the building and to counteract the outward thrust of the rafters. Sometimes these floor joists are dropped below the wall plate *F*, and are supported on a ledger board notched into the wall studding *I*. This construction is not so good as that shown in the figure, because the joist is not so effective as a tie across the building. If it is employed the floor joist must be securely nailed to the wall studding *I*, and they must not in any case be dropped more than 2 or 3 feet below the plate. The plate must

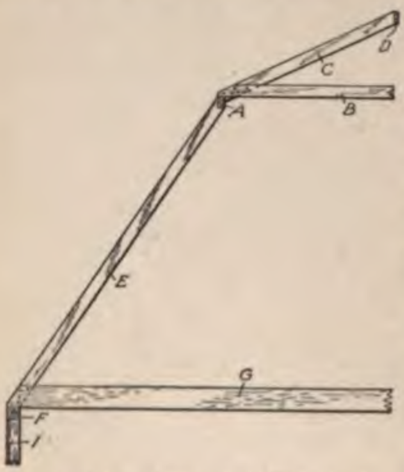


Fig. 185. Framing for Gambrel Roof

always be firmly nailed to each stud to prevent it from being forced outward as it receives the thrust from the rafters *E*.

A good rule for determining the point at which to place the secondary plate, and for determining the general shape of the roof, is illustrated in Fig. 186. Let the points *A* and *B* represent the main plates on each side of the building. Draw a line *A B* between them and bisect this line at *C*. With *C* as a center and *C A* as a radius describe the semicircle *A D E F B*. At any distance *G* above *A B* draw a line *D F* parallel to *A B*, cutting the semicircle at the points *D* and *F*. Also bisect the arc at *E*. Then by joining the points *A D E F* and *B* by straight lines as shown, we will have the outline of a gambrel roof. The proportions of the roof may be varied by varying the distance *G*.

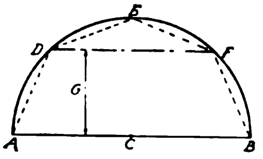


Fig. 186. Method of Finding Contour for Gambrel Roof

Gambrel roofs are not very strong unless they are stiffened by cross partitions in the attic stories, and these should be provided whenever it is possible. No gambrel roof, unless it is well braced, should be used on a building which is exposed to high winds, or which is likely to receive a heavy weight of snow.

Mansard Roof. A mansard roof is framed in very much the same way as is a gambrel roof, as may be seen in Fig. 187. Resting on the main wall plate *A*, we have a piece *B* which is inclined slightly inward, and which supports at its upper end a secondary plate *C*. On the plate *C* rests the outer end of the deck rafter *D* which is nearly horizontal. The piece *B* is a piece of studding, 2×4 inches to 4×6 inches in size, depending upon the size of the roof. It supports the whole weight from the rafters, carrying this weight to the main wall plate and thence into the walls of the building. This member should always be straight, and the curved shape which is usual on mansard roofs is obtained by the use of the furring piece *E*. The piece *E* is nailed to the upright member *B* at the top, and at the

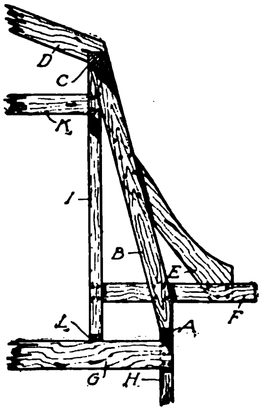


Fig. 187. Framing for Mansard Roof

bottom it is secured to the lookout *F*, which also forms a support for the projecting cornice. The floor joist *G* is supported on a ledger board *H*, or it may rest directly on the plate *A*. The piece of studding *I* is merely a furring stud to form the wall of the attic room. It may be omitted entirely if desired, or if the attics are to be unfinished. The ceiling joist *K* may be supported on a ledger board as shown, or may be simply spiked to the studding *I* or to the upright *B*. The studding *I* may rest directly on the floor joist *G* with a sole piece *L* at the bottom as shown. The plate *C* should be of a good size, at least 4×6 inches, and should not be placed more than 2 or 3 feet above the ceiling joists *K*. The ceiling joists act as ties across the building and prevent the plates *C* from spreading apart, as they receive the thrust from the rafters *D*. For this reason it is better to have the ceiling joist *K* fastened to the upright *B* rather than to the furring stud *I*.

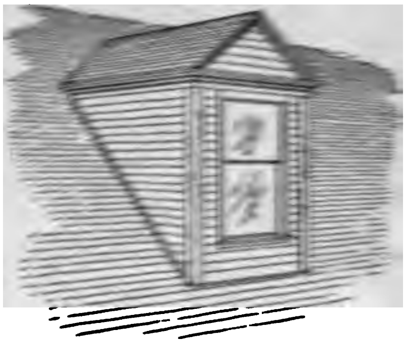


Fig. 188. One Form of Dormer Window

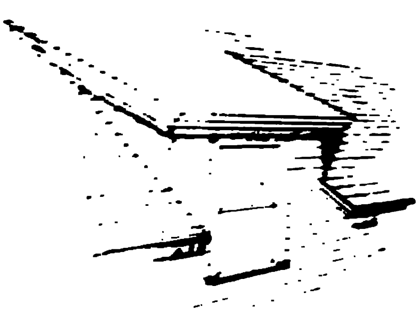


Fig. 189. Another Form of Dormer Window

Dormer Windows. In Figs. 188 and 189 are shown what are known as dormer windows, this name being applied to all windows in the roofs of buildings, whatever may be their size or shape. The figures show two different kinds of dormer windows which are in general use, the one shown in Fig. 188 resting entirely on the roof, while the one shown in Fig. 189 is merely a continuation of the wall of the building above the line of the eaves. The second type is often seen on buildings only one story in height, while the other kind is employed on larger structures.

In order to construct a dormer window an opening must be made in the roof surface, and the window must be built up over the opening. Headers are framed in between two of the rafters as shown at *A* and *B* in Fig. 190, and thus a rectangular opening is formed in the roof frame. The rafters *C* and *D*, which form the sides of the opening, are called trimmers and should be much stronger than the common rafters. Usually the trimmers are made by doubling the ordinary rafters. The headers receive the ends of the rafters which are cut by the opening, and must be large enough to carry the weight which comes from them besides supporting the walls of the dormer. Timbers 4×8 inches to 6×10 inches, according to the size of the dormer, are usually large enough for the headers and often smaller timbers may be safely used.

The headers are shown in section at *A* and *B* in Fig. 191, and it will be noticed that they are not used in exactly the same way. The piece at the top *A* is so placed that its longer dimension is at right angles to the plane of the roof, while the piece at the bottom *B* has its longer dimension vertical. In the case shown in Fig. 189, where the front wall of the dormer is merely an extension of the main wall of the building, there is no need of the lower header *B*, the main wall plate taking its place and supporting the studding for the front wall of the dormer, as shown at the right-hand side of Fig. 191.

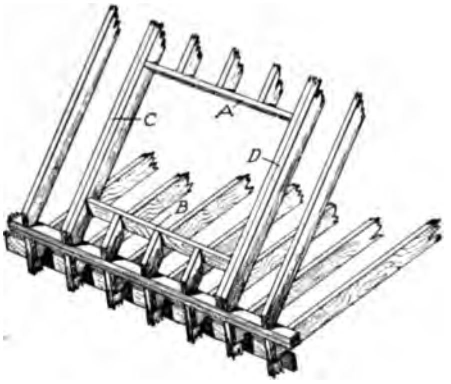


Fig. 190. Roof Framing for Dormer Window

Fig. 191 shows sections taken through two dormers of the types mentioned above, parallel to the direction of the main rafters and at right angles to the main wall plate of the building. At the left is a section taken through the type of dormer shown in Fig. 188, while at the right a section of the other type is shown. The studs *C C* which form the side walls of the dormer, are notched over the trimmer rafters and roof boarding about 1 inch, and allowed to continue downward to the attic floor. This is shown at section *D D.* At *E* is a section of the trimmer rafter, *C* is the wall stud, *G* is the attic floor boarding, and *H* is a section of one of the attic floor joists. The studs *C* are in line with the studs forming the side walls of the attic room, so the studs *I* can not be carried down to the attic floor. They are stopped, at the bottom, against a 2×3 inch strip *K* which is nailed to the side of the trimmer rafter. At *L* is the ridge board, and *M M M* are the short rafters which form the pitch roof of the dormer. They may be very light, as they are short and carry little weight. They rest, at the foot, on a plate *O*, and at the top bear against the ridge board *L*. In the dormer shown on the right of the figure the rafters *P* are in planes parallel to the main rafters, and a furring piece *S* may be nailed to each of them so as to give the dormer roof any desired curve.

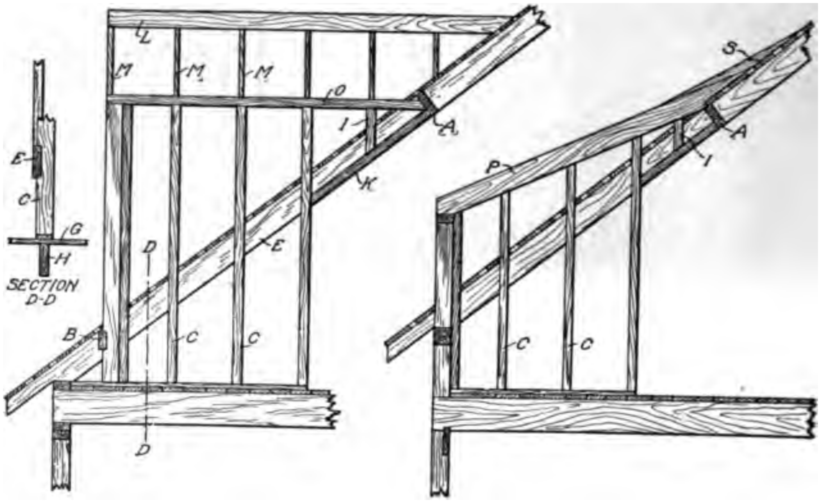


Fig. 191. Framing Details for Both Types of Dormer Windows

Besides the openings in the roof frame for dormer windows there must be other openings for chimneys and skylights. These are formed in the same way as explained for the dormer openings, with headers and trimmer rafters. A plan of such an opening is shown at *E* in the roof framing plan in Fig. 174.

RAFTERS

The ends of rafters are usually cut to fit accurately against one another and against the plates on which they rest. The cutting of these bevels is not at all difficult when the relation of the rafter to the roof surfaces is seen and the steel square is used to show this relation.

Common Rafters. *Method of Cutting Bevel.* Fig. 192 shows the bevels that are used on the common rafters in a simple gable roof such as is illustrated in Fig. 163. In Fig. 191, *B* is the plate and *E* is a point midway between the two plates, and the distance *D E* is the run of the common rafter *C*. *P* is the point where the line drawn through *D* parallel to the edges of the rafters is directly above the point *E*. The distance *D P* is usually taken as the length of the rafter.

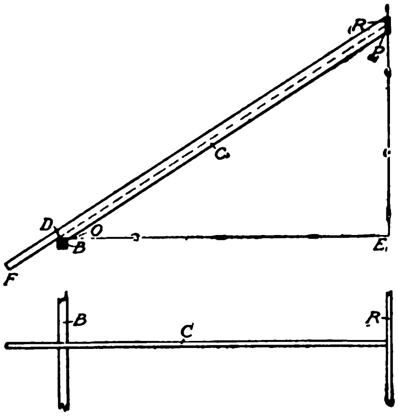


Fig. 192. Diagram Showing Bevel Used on Common Rafters

The length is taken from these points because the distance *D E* represents the exact run and *E P* represents the rise for this run.

The first step to take in laying out the rafter is to locate the point *D* on the uncut piece as shown in Fig. 193. The point is chosen so that it is far enough from the end to form the eaves *F D*, and the distance *T D* is usually taken 2 inches on a 2 × 4 inch and 3 inches or more on larger size rafters. It is well to remember that the measurement is to be taken from the top in order that the roof surface may always be even and smooth throughout. Now the edge of the blade of the square must coincide with *D*, but the position which the square will take depends entirely on the pitch.

In all cases 12 inches is used on the blade of the square and the figures on the tongue depend on the rise per foot of run. If the rise of the rafter is 12 inches to the foot, 12 inches should be used on the tongue also. If the rise is 10 inches, use 10 inches on the tongue. In the cut the rise is 8 inches to the foot, the run is 12 feet, the rise is 8 feet, and 12 and 8 are the figures used.

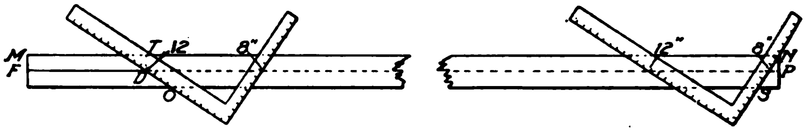


Fig. 193. Method of Laying Out Rafter with Steel Square

Usually the carpenter uses the edge *M N* to obtain this bevel but the line *F P* may also be used. The line *D O* is the heel or plate cut, as shown in Figs. 192 and 193. The rafter is sawed along the lines *F D* and *D O*. Now the next step is to find the length *D P*. This may easily be determined by any one of four methods. The easiest of these is to turn to the rafter table on the square. Opposite 12—8—$\frac{1}{3}$ and under the 12 (indicating feet run) the length is given as 14 feet 5 inches. By extracting the square root of the sums of the square of rise and run the same result is obtained. The third

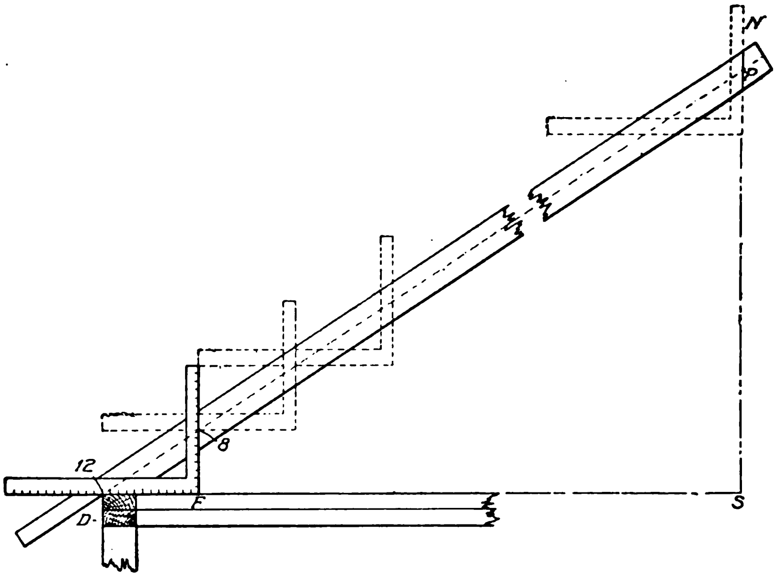


Fig. 194. Method of Cutting the Bevel at the Top of the Rafter

way is to measure the distance in inches and twelfths from the 12 on the blade of the square to the 8. Each inch represents one foot of length and each twelfth represents 1 inch. The distance is 14 feet 5 inches. The fourth method is to use the method illustrated in Fig. 194. First locate the line *DP* and then beginning at *D* move the square along the edge of the rafter as many times as there are feet and fractions of feet in the run; thus the point *P* is determined.

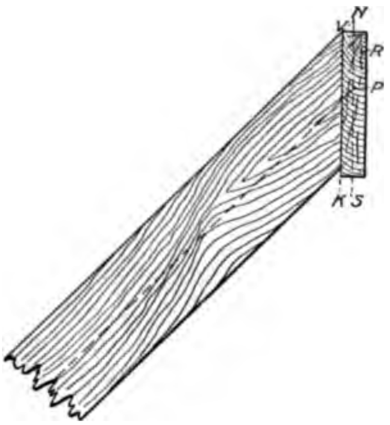


Fig. 195. Fitting a Rafter against Ridge Board

A little study of the figures will suffice to reveal to anyone the reason for this method of procedure. Every time the square is moved into a new position it has advanced 12 inches or 1 foot along the run of the rafter, since the distance *D E* is 12 inches and is measured horizontally. After the square has been moved twelve times it has advanced 12 feet along the run of the rafter or the distance required. This gives the position of the top bevel. It should be noticed that for a run of 12 feet the square must be moved along twelve times; for a run of 8 feet, eight times; and so on. The run of the rafter may be easily obtained by subtracting one-half the

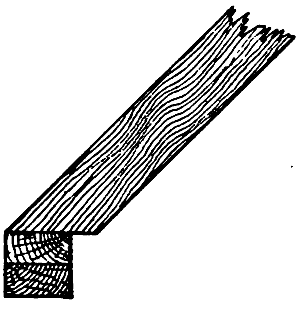


Fig. 196. Cutting Rafter for Concealed Gutter

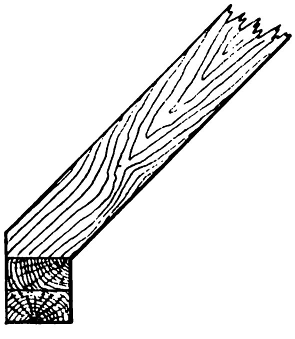


Fig. 197. Another Method of Cutting Rafters for Concealed Gutter

thickness of the ridge board from one-half of the total span of the roof from outside to outside of wall plates.

Fig. 194 shows the rafter in the position which it would occupy in a building, the plate and a part of the wall studding being indicated. When the rafter is cut along the line *N S*, Fig. 193, it is ready to be put on the building. In case, however, that a ridge board is used to hold the rafter in place, as shown by *R* in Fig. 192, the rafter is cut parallel to *N S* but shorter, as shown in Fig. 195, one-half of the thickness of the ridge board being cut away. The cut at *D O*, Fig. 192, is horizontal, and the bevels at *NS* and *VK*, Figs. 193, 194, and 195, are plumb cuts.

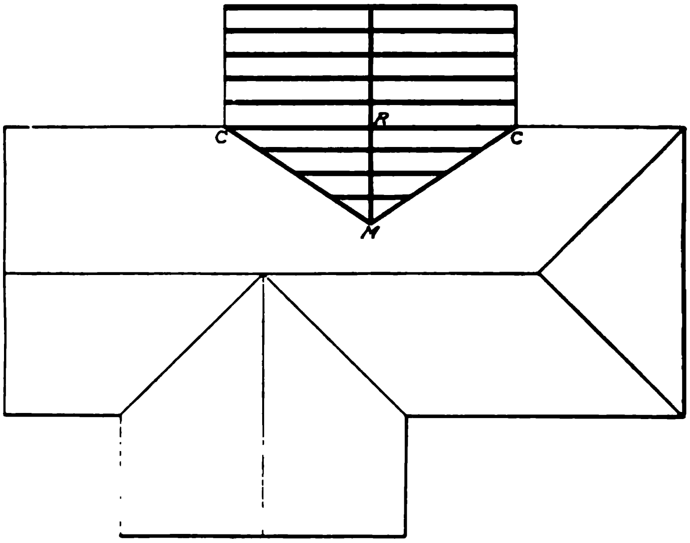


Fig. 198. Bevels for Valley and Hip Rafters

In case a concealed gutter is used and the rafter is set directly over the wall, the line *D P* coincides with the line *M N*, Fig. 193, and the rafter has only the horizontal cut at the bottom or a horizontal and vertical cut, as shown in Figs. 196 and 197.

Valley and Hip Rafters. In Fig. 198 the rafters *C C* are valley rafters and, although the bevels for these rafters are not the same as the common rafter in either roof surface, yet the bevels depend upon the relation between the common rafters and the valley rafters.

It is best to consider the common rafter as the hypotenuse of a right triangle or as the diagonal of a rectangle whose length is the run of the rafter and whose width is the rise of the rafter. In studying the valley rafter it is evident that there are three dimensions to be considered. Rafter *C* extends to the right to the ridge of the main roof besides rising. It may, therefore, be considered as the diagonal of a rectangular solid. For instance, if the run of the common rafter is 12 feet, the rise 10 feet, and the distance *MR* is 8 feet, the valley rafter will form the diagonal of a rectangular solid 12 inches × 10 inches × 8 inches, and its length and bevels can be found as shown in Figs. 199 and 200. In Fig. 198 we find the run which is the hypotenuse of the triangle *CRM*. That is, the run of the valley rafter is taken from the distance between the 12 and 8 on the square. It is $14\frac{5}{12}$ inches, showing that the run of the valley is 14 feet 5 inches. Now the rise is the same as the rise of the common rafter *CR*. That is, it is 10 feet and the bevel at the foot of the rafter is cut along the blade of the square when the figures read $14\frac{5}{12}$ inches on the blade and 10 inches on the tongue.

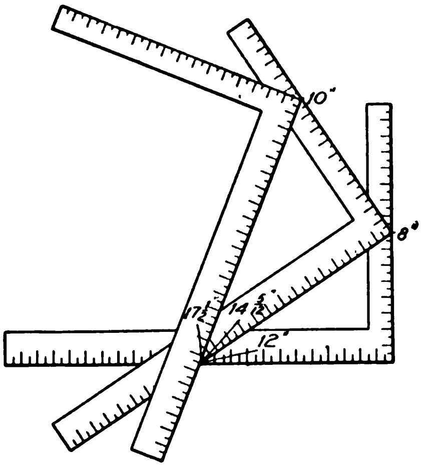


Fig. 199. Method of Finding Bevels for Various Runs of Rafters

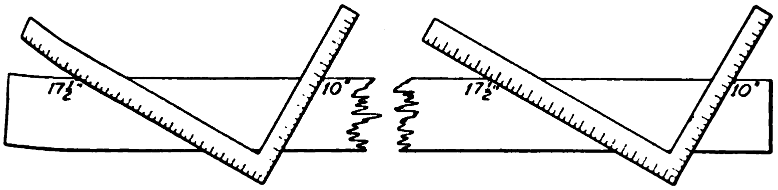


Fig. 200. Cutting Bevels on Common Rafter

The plumb cut at the top of the rafter is made by holding the square in the same position and cutting along the tongue.

The length of the rafter is determined either by measuring the distance from the $14\frac{5}{12}$ and 10 on the square or by finding the square root of the sums of the squares of the three dimensions. The latter method gives $\sqrt{144+100+64}=17.5=17$ feet 6 inches (approx.).

The layout of a hip rafter is the same in principle as the layout of a valley rafter. To find the run of a hip rafter, find the diagonal of a square whose sides are equal to the run of the common rafter. That is, if the run of the common rafter is 10 feet, the run of the hip rafter is the hypotenuse of a right triangle whose sides are 10 feet and this distance is 14.14 feet or 14 feet 1⅔ inches. The rise of the hip is the same as the rise of the common rafter. If, then, the rise is 8 feet, use 14⅛ inches on the blade and 8 inches on the tongue to lay off the horizontal and the plumb cuts. The length of the hip is the hypotenuse of the triangle between the 14⅛-inch mark on the blade and the 8-inch mark on the tongue. To compute this mathematically we have $\sqrt{10^2+10^2+8^2}=\sqrt{264}=16.25$ feet, or 16 feet 3 inches.

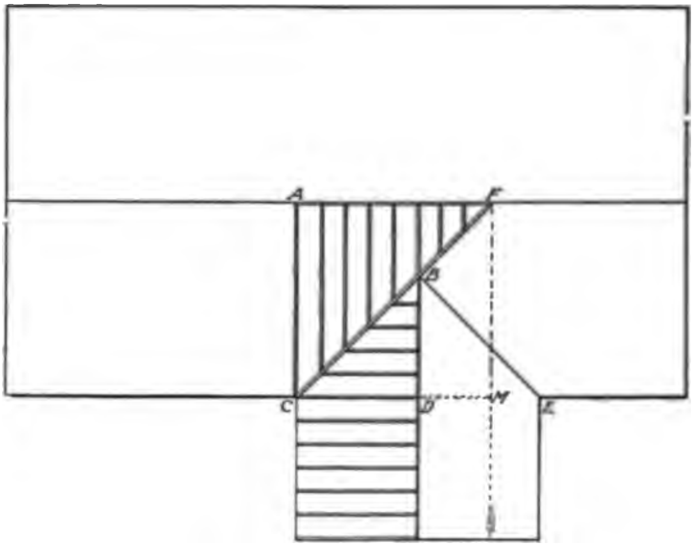


Fig. 201 Plan for Valley Rafter Connecting Two Roofs of Unequal Pitch and Width

When a valley rafter serves to connect two roofs of unequal pitch and width, the problem is more complex. In Fig. 201 a 10×12 foot roof covers the main building and an 8×12 foot roof covers the ell on the left. The rise of rafter *AC* is 13 feet 4 inches, the rise of rafter *C D* is 7 feet 6 inches, and the ridge of the main roof is nearly 6 feet above the ridge of the ell.

One of the valley rafters *C F* runs to the ridge of the main roof, its rise being 13 feet 4 inches. In extending to *F* the valley runs 16 feet toward the main ridge, and the distance *A F* is found by proportion or by drawing the plan to scale and measuring.

In using proportion, take the run of the common rafters *A C* and *C D*. If the ridge of the ell roof coincides with the ridge of the main roof, the common rafter *C M* would be in proportion with *C D*, thus:

$$\text{Rise of } C\,D : \text{rise of } C\,M :: \text{run of } C\,D : \text{run of } C\,M$$

Substituting

$$7'\text{-}6'' : 13'\text{-}4'' :: 10' : \text{run of } C\,M$$

$$90 : 160 :: 120 : \text{run of } C\,M$$

$$\therefore \quad \text{Run of } C\,M = 213\tfrac{1}{3}''$$

$$= 17'\text{-}9\tfrac{1}{3}''$$

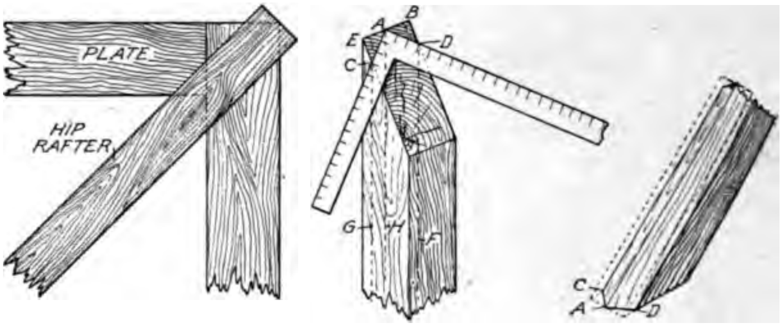
Now find the diagonal distance *C F* by mathematics or the use of the square. On the square use 17¾ inches on the blade and 16 inches on the tongue.

The distance is 23 feet 11 inches. The rise is 13 feet 4 inches. Hence, use $23\tfrac{11}{12}$ inches on the blade and $13\tfrac{1}{3}$ inches on the tongue to give the horizontal and plumb bevels and length of the valley.

To cut the side bevel at the top, use the distances *C M* and *A C*, cutting along the *C M* side. In order, however, that this cut can be made accurately, the rafter must be backed and the square laid on the backed surface. Few carpenters, if any, ever back a valley rafter and consequently a roundabout method is used to get this bevel. The common result is, that the bevel very rarely fits snugly against the ridge. Where the rafter is not more than 2 inches thick, the misfit is not so noticeable, but in 4-inch material the open joint must be "doctored" by gauging and resawing after it has been tried.

When the rafter is cut properly and set in place it will be found that the plane of its top surface does not lie in either of the two roof surfaces. The surface of the top lies at an equal angle to each roof surface and one edge extends up above the other rafter in both roofs.

Fig. 202A shows how the edges of a hip rafter extend over the plate at the bottom. To overcome this the rafter can be backed or cut shorter as shown in Figs. 202B and 202C. To back the rafter, lay the square on the bevel at the bottom end in the position the plate will occupy. Now mark the points *C D* and draw the lines *D F* and *C G* from these points parallel to the edge of the rafter and cut away the triangular part *A B D F H* and *A E C G H*. This is an expensive means of making the rafter conform to the roof surface and most carpenters merely shorten the rafter until the outside corners conform to the surfaces, as shown in Fig. 203.



A B C

Fig. 202. Cutting Rafter to Prevent Ends from Projecting Over Plate

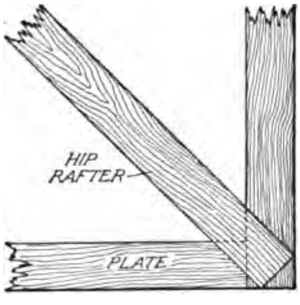


Fig. 203. Simpler Method of Avoiding Projecting Hip Rafter

If the rafter is not to be backed, the effect of backing can be easily obtained by nailing a thin board on the top of the rafter and giving this board the proper bevel. The method is illustrated in Fig. 204.

The clapboard *A* is nailed at the edges and the one side wedged up to the angle the backing would take, care being taken to allow the square to touch the edge *B B* of the rafter at *C C*. The square used on the side of the rafter gives the plumb cut *C D*, and *C M* over the clapboard gives the side bevel. In cutting, the saw is held at an angle to coincide with both *C D* and *C M*.

In the rafter *B E*, Fig. 201, the horizontal cut at *E* is obtained by using 23 feet 11 inches and 13 feet 4 inches and is the same as the cut at *C*. The length of the rafter can be found by using proportion or by finding the length of *B D*.

In using proportion, it is evident that *B E*, the run of the short valley, is to *C F* as 7 feet 6 inches, or 90 inches, is to 13 feet 4 inches, or 160 inches.

$$\therefore \qquad BE:287::90:160$$

$$BE=\frac{287\times 90}{160}=161.5 \text{ inches}=13 \text{ feet } 5\tfrac{1}{2} \text{ inches}$$

The rise is 7 feet 6 inches and the run is 13 feet 5½ inches.

Another way in which the problem may be solved, is to find where the ridge of the ell intersects the main roof surface. The intersection is at a height of 7 feet 6 inches which is $\frac{90}{160}$ of the run of *A C*, or ^{9} of 16 feet and the distance *B D* is just 9 feet. Hence, the run of *B E* is $\sqrt{10^2+9^2}=13.45=13$ feet 5½ inches, and this is $\frac{9}{16}$ of the run of the rafter *C F*. Hence, the run of *C F* is $13.45\times\frac{16}{9}=23$ feet 11 inches.

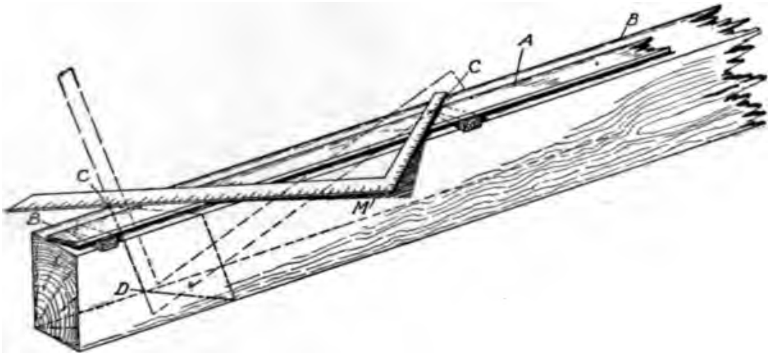


Fig. 204. Method of Using Clapboard to Cut Bevel on Rafter

The end cut at *B* on *B E*, that is, the bevel that fits against *C F*, to be cut accurately, must be handled like the side bevel at *F*. First cut the bevel at the plate and get the backing line that makes *B E* lie in the main roof surface. Now, at *B*, either back the rafter a short distance, or use a clapboard as in Fig. 204.

Jack Rafters. Fig. 205 shows the plan of the roof in which there are, in addition to hip and valley rafters, sets of jack rafters. *A B* and *B D* are hip rafters, *C E* is a valley rafter, and the other rafters are common and jack rafters. At *B E* and *E H* are shown the ridge boards. Of the jack rafters there are three different kinds: those like *I J* which run from the valley rafter to the ridge board; those like *K L* which run from hip rafter to plate; and those like *N T*, which run between the hip and valley rafters. These jack rafters differ only in respect to the bevels which have to be cut on them. The rafter *I J* is a simple plumb cut at the top, similar to the cuts at the top of the common rafters, and at the bottom where the rafter meets the valley there are two cuts—a plumb cut and the side cheek cut—which are similar to the cuts in a valley rafter where it comes against a ridge board. This cut has been previously explained.

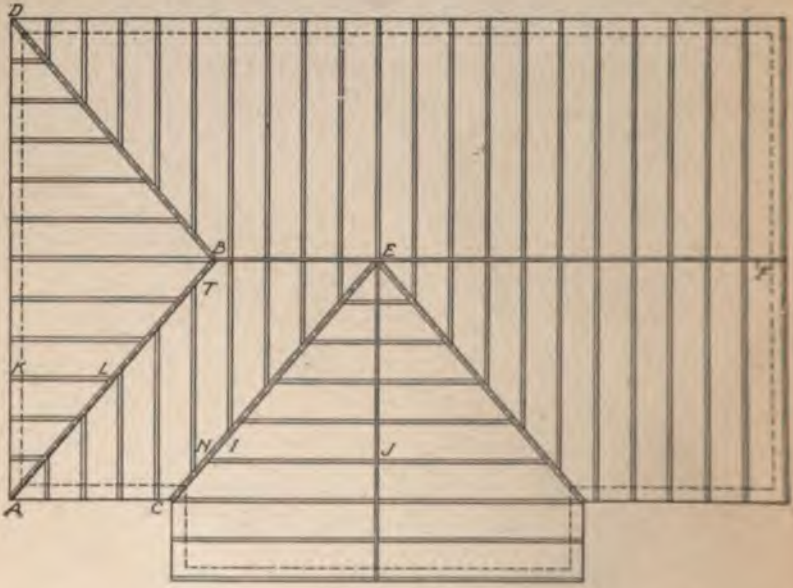


Fig. 205. Roof Plan Showing Hip and Valley Rafters and Jack Rafters

The rafter *K L* has a simple horizontal cut at the bottom like that used on the common rafter, but at the top there are two cuts similar to those at the foot of rafter *I J*. The rafter *N T* has two cuts at both top and bottom. All these bevels are obtained just as the bevels for the hip and valley rafters.

The length of a jack rafter is proportional to its distance from the ridge or plate to which it is parallel. The longest jack rafter is

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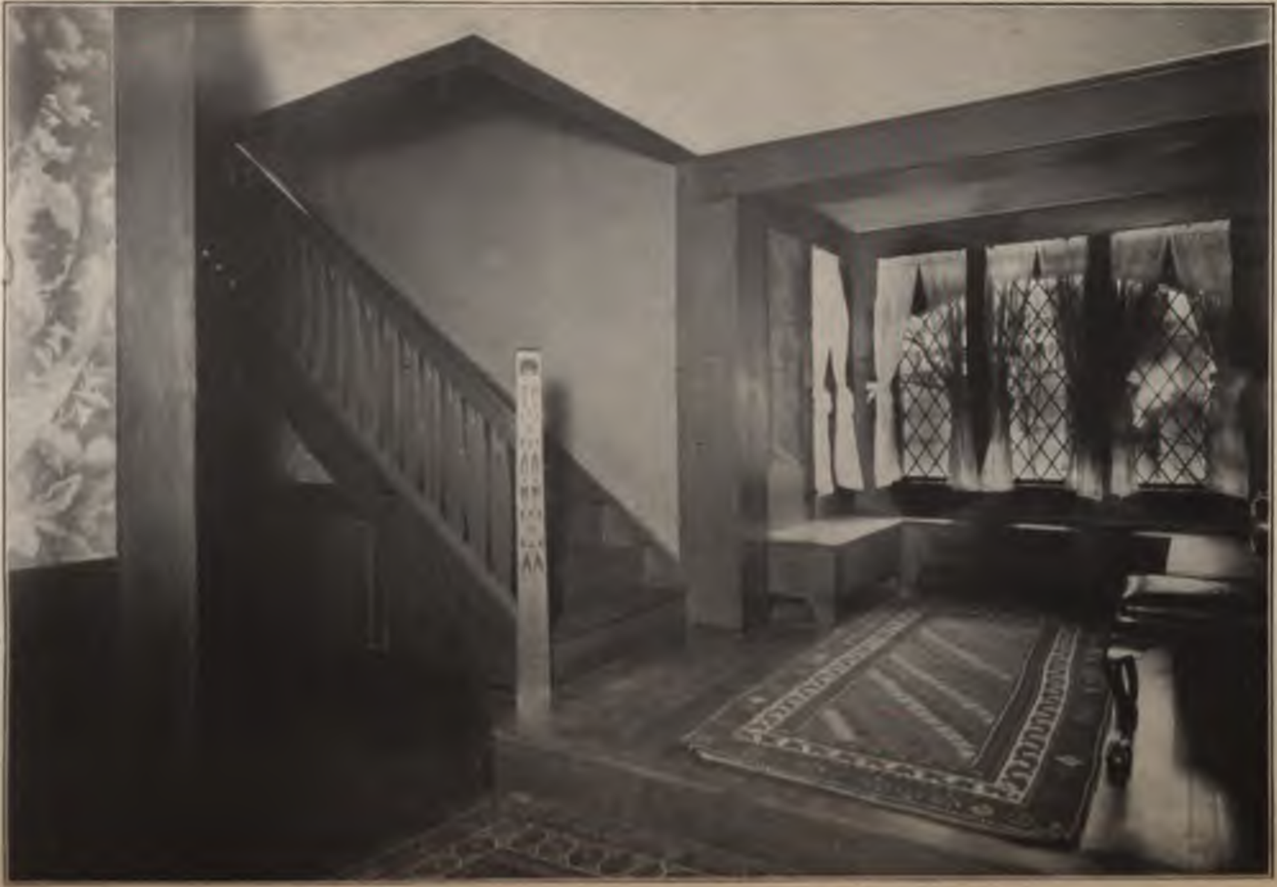


STAIR HALL IN RESIDENCE OF MR. C. H. THOMPSON, CAMBRIDGE, MASS.
Cram, Goodhue & Ferguson, Architects, Boston and New York

equal in length to a common rafter, and the length steadily decreases as the distance of the rafter from its first full length rafter. The exact difference in length between the first jack rafter and the next, is determined by finding how far apart the jack rafters are to be placed, and comparing this distance with the distance from the top of the first full length jack rafter to the point where the hip or valley rafter rests on the ridge board or plate. Suppose, for instance, that the rafters are to be spaced 2 feet apart, and the length of the common rafter is 10 feet. If the distance from the top of this rafter to the point where the valley rafter is fitted against the ridge is 12 feet, it is evident that each rafter will be 2 feet shorter. That is, the second rafter will be 8 feet and the next 6 feet and so on. We use six spaces, although there are only five rafters, there being no rafter used where the valley and ridge join.

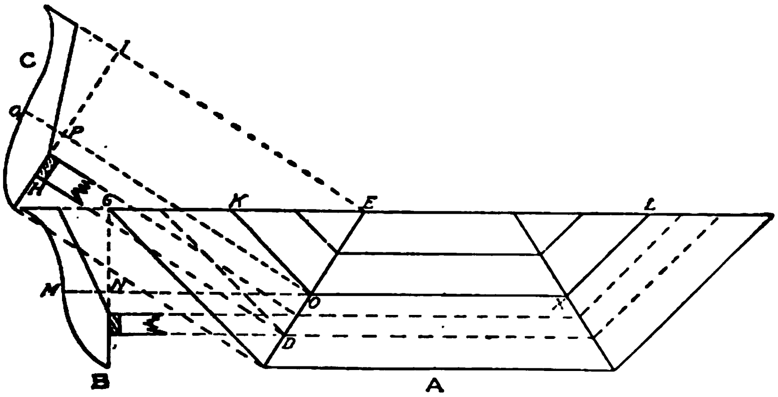


Fig. 206. Roof Plan Showing Rafters Cut for Ogee Roof

Curved Hip Rafters. A form of hip rafter which is sometimes a source of considerable trouble is one which occurs in a curved roof, such as an ogee roof over a bay window, or a curved tower roof. The slope of the curve to which the top edges of the common rafters must be cut, is determined from the shape of the section of the curved roof surface, but the curve at the top of the hip rafter is entirely different and must be determined in another way. The principle used in finding this curve is the same as was employed in the case of the valley rafter, namely, that any line drawn in the roof surface parallel to the wall plate must be horizontal, or that it must be exactly the same elevation throughout its entire length.

Fig. 206 shows how this may be applied. At *A* is shown a plan of an ogee roof over a bay window with a hip rafter *D E* and common rafters. At *B* is shown an elevation of one of the common rafters cut to coincide with the curve of the roof surface. The shape of the curve may be varied to suit the fancy of the designer. At *C* is shown an elevation of the hip rafter *D E*, showing the curve to which it must be cut in order to fit into the roof.

To determine this curve we draw on the roof plan at *A* any number of lines, parallel to the wall plate. These must be horizontal, so that any point in either of the lines is at the same height above the top of the plate as in every other point in the same line. The lines *F G* and *H I* in the elevation, shown at *B* and *C*, represent the level of the top of the plate. By projection we find that the line *K O N L*, for example, is at a distance *M N* above the top of the plate at the point where it crosses the common rafter shown at *B*. Every other point in this line is at the same elevation, including the point *O*, in which it intersects the center line of the hip rafter *D E*. By projection we can locate the point *O* in the elevation shown at *C*, making the distance *O P* equal to the distance *M N*.

In the same way we can obtain as many points in the curve of the hip rafter as we have lines drawn on the roof plan. The lines may be drawn as close together as we wish, and the number of points obtained may thus be increased indefinitely. When a sufficient number of points have been located, the curve can be drawn through them, and a pattern for the hip rafter is thus obtained. The shape of the curve for a valley rafter is found in the same way as explained for a hip rafter.

ATTIC PARTITIONS

It is often necessary to build partitions in the story directly beneath the roof, and such partitions must extend clear up to the under side of the rafters and be connected with them in some way. This makes it necessary to cut the tops of the studs on a bevel to correspond with the pitch of the rafters, and the cutting of this bevel is not always an easy task. Fig. 207 shows the framing plan of the roof of a small simple building. In this figure *A B* is the ridge. The plate extends around the outside from *C* to *D* to *E* to *F*, and back again to *C*; and *G H I J K L* are the rafters. A partition *H M* is shown beneath the roof running diagonally across the building, making an angle with the direction of the rafters and an angle with the direction of the ridge. At *N O* is shown another partition running parallel to the ridge, and at *P Q* still another, running parallel to the rafters. Now since all the rafters slope upwards from the plate to the ridge, it is evident that the tops of all the studs must be cut on a bevel if they are to fit closely against the under sides of the rafters. This is illustrated in Fig. 208, where the stud *A* must fit against the rafter *B*.

To take the simplest case first, let us consider the stud marked

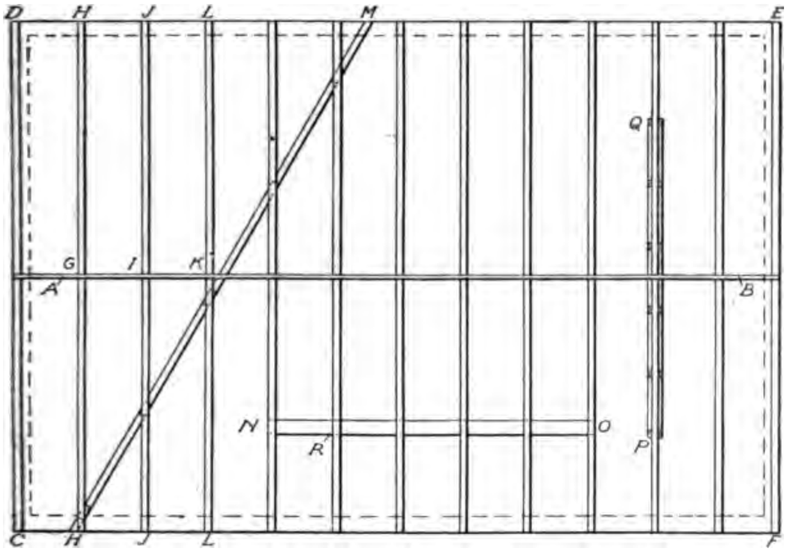


Fig. 207. Framing Plan of Roof of Simple Building

R, Fig. 207. Since all the rafters have the same pitch or slope, all the studs in the partition *N O* will have the same bevel at the top, and if we find the bevel for one we can cut the bevel for all. Fig. 208 shows this stud drawn to a larger scale and separated from the rest; *A B D C* is a plan of the stud, and the rafter is shown at *E F H G*. We will take the distance *F H*, or the run of the part of the rafter shown, as one foot exactly. Now if A_1 and B_1 represent a side elevation of the rafter and stud, the run of the part of the rafter shown is the distance *J Q*, and the distance *Q O* should be equal to the rise of the rafter in one foot. Let the rise in this case be 9 inches. Then $K\ N$ shows the bevel of the top of the stud. If the stud is a 2×4 stick, the distance $K\ R$ is just 4 inches or one-third of the run of the rafter, and consequently the distance $R\ N$ is just 3 inches, or one third of the rise of the rafter.

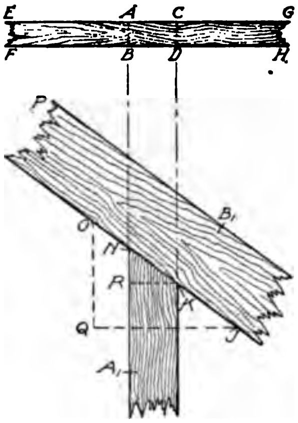


Fig. 208. Studs Beveled to Fit Under Side of Rafter

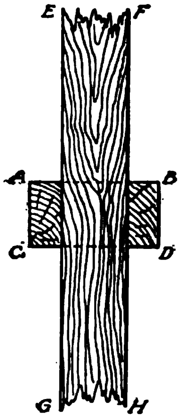


Fig. 209. Cutting Studs for Partition Running Parallel to Rafter

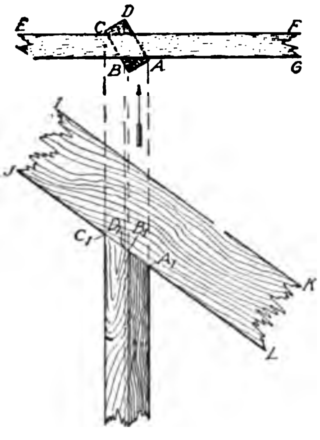


Fig. 210. Cutting Studs for Partition Running Diagonally

In the case of the studs forming the partition $P\ Q$ in Fig. 207, the bevel is found in the same way, the only difference being that the rafter now crosses the stud, as shown in Fig. 209, where $A\ B\ C\ D$ is the stud and $E\ F\ G\ H$ the rafter, both shown in plan.

In the case of the partition $H\ M$, Fig. 207, we have to deal with a somewhat more difficult problem because the rafter crosses the stud diagonally and the studs must be beveled diagonally on top so that the bevel will run from corner to corner instead of straight across the stud from side to side. An enlarged plan of one stud with the rafter running across it is shown in Fig. 210. Let $A\ B\ C\ D$ be the stud and $E\ F\ G\ H$ the rafter; $I\ J\ L\ K$ shows the rafter in elevation looking in the direction shown by the arrow, and $A_1 B_1 C_1 D_1$ shows the stud as seen from this same direction. The edge D_1 of the stud can not be seen from this side and is shown as a dotted line in the figure. The rafter runs across the stud, thus giving the bevel $A_1 B_1 C_1 D_1$ as shown in the figure.

SPECIAL FRAMING

We have, in the preceding pages, considered the framing which enters into a building of light construction, such as an ordinary dwelling house, but there are certain classes of structures which call for heavier framing, or framing of special character. Among these may be mentioned battered frames, or frames with inclined walls; trussed partitions; inclined and bowled floors; special forms of reinforced beams and girders; the framing for balconies and galleries; timber trusses, towers and spires, domes, pendentives and niches; and vaults and groins. These subjects will now be taken up and discussed, and the methods employed in framing such structures will be explained.

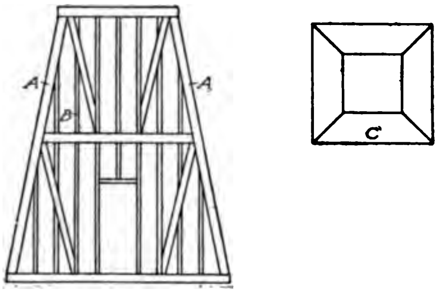


Fig. 211. Battered Frame

Battered Frames. Sometimes it is necessary to build a structure with the walls inclined inward, so that they approach each other at the top, and so that the top is smaller than the bottom. This is the case with the frames which support water tanks or windmills. An elevation of one side of a frame of this kind is shown in Fig. 211 with a plan in outline at *C*. It will be seen that the corner posts *A A* are inclined so as to approach each other at the top, and that they are not perpendicular to the sill at the bottom. This means that the foot of the post, where it is tenoned into the sill, must be cut on a bevel, and the bevel must be cut diagonally across the post, from corner to corner, since the post pitches diagonally toward the center, and is set so that its outside faces coincide approximately with the planes of the sides of the structure as indicated in the plan shown in Fig. 212. The girts *B*, Fig. 211, will also have to have special bevels cut at their ends, where they are framed into the posts.

After a corner post has been cut to the proper bevel to fit against the sill the section cut out at the foot will be diamond shaped, as shown at *A B C D* in Fig. 212, which shows a plan of one corner of the sill. It will be noticed that the faces *A B* and *A D* of the post do not coincide with the edges of the sill *A F* and *A G*. If the structure is merely a frame and is not to be covered over with the boarding on the outside, it is not necessary that the outside faces of the post should coincide exactly with the planes of the sides of the structure, and in this case posts of square or rectangular section may be used, with no framing except the bevels and the mortises for the girts. If, however, the frame is to be covered in, the post must be backed in order that it may be prepared to receive the boarding.

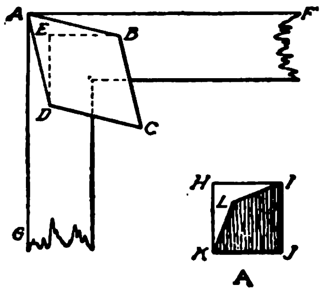


Fig. 212. Battered Frame Detail

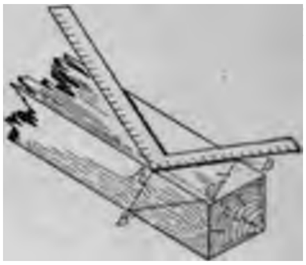


Fig. 213. Method of Cutting Foot of Inclined Post by Steel Square

The backing consists in cutting the post to such a shape that when the bevel is cut at the foot, the section cut out will be similar to that shown at *E B C D* in Fig. 212. The backed post must then be set on the sills so that the point *E* will come at the corner *A*. The face of the post *E B* will then coincide with the face of the sill *A F*. The post should be backed before the top bevel is cut because setting it back the distance *A E* may make a difference in the required length between bevels. If the post is of square section before backing it will have, after backing, a peculiar rhombus-shaped section, as is shown at *A* in Fig. 212. Here *H I J K* shows the original square section, and *L I J K* shows the section after backing. These sections are taken square across the post perpendicular to the edges.

Fig. 213 shows how the foot cut for the inclined post may be obtained by using the steel square. In Fig. 211 it will be seen that the post *A* slopes toward the center in the elevation there shown, and it likewise slopes toward the center in the other elevations, either with the same pitch or with a different pitch. The result of the two slopes is to cause the post to slope diagonally. It is an easy matter to find the pitch in each elevation since it depends upon the size of the base and top, and the height between them. We then have the two pitches, the combination of which gives the true pitch diagonally; they can, however, be treated separately. The square may be applied to the post, as shown in Fig. 213, with the rise on the blade and the run on the tongue, and a line may be drawn along the tongue. The post can then be turned over and the pitch shown in the other elevation may be laid off on the adjacent side in the same way, with the rise on the blade and the run on the tongue of the square. Thus a continuous line *A B C D* may be drawn around the post and it can be cut to this line.

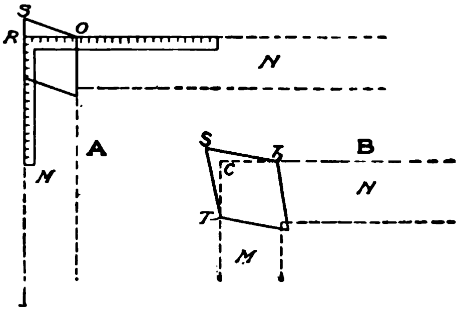


Fig. 214. Method of Finding Amount of Backing for Post

Fig. 214 shows how the amount of backing necessary in any particular case may be determined. Suppose that we have a case where the plan of the frame is not square, as shown in Fig. 211, but is rectangular, one side being much longer than the other. In this case the diagonal of the frame formed by the sills will not coincide with the diagonal section of the post. Fig. 214 shows at *A* a plan of the post as it would appear if it were set up with one edge perpendicular to the sill *M*, after the bottom bevel is cut. To cut the backing, lay the steel square along the side of the post parallel to

M, and so as to coincide with the opposite corner *O*. When the triangular piece *R S O* is cut away, the backing is complete. At *B* is a plan where the post is set with corners *T T*, so as to coincide with the outside edges of the plate. To back the post in this position, place the square so as to coincide with the points *T T*, making the distance *C T* and *C T* proportional to the lengths of the sills *M* and *N*. In this case, the backing consists in cutting away the area *S T C T*.

Trussed Partitions. It is very often necessary to construct a partition in some story of a building above the first and in such a position that there can be no support beneath it such as another partition. In this case the partition must be made self-supporting in some way. The usual method is to build what is known as a "trussed partition." This consists of a timber truss, light or heavy according as the distance to be spanned is small or large, which is built into the partition and covered over with lathing and plastering or with sheathing.

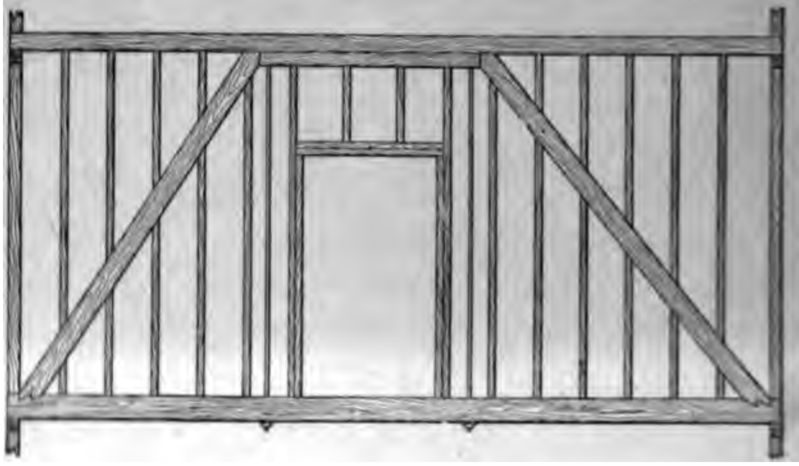


Fig. 215. One Form of Trussed Partition

Figs. 215 and 216 show two forms of trussed partitions which are in common use. The one shown in Fig. 215 may be employed for a solid partition, or a partition with a door opening in the middle, while the one shown in Fig. 216 is applicable where the wall must be pierced by door openings in the sides. The truss must be so designed that it will occupy as little space as possible in a lateral direction, so that the partition need not be abnormally thick. If possible, it is best to make the truss so that it will go into a 4-inch partition, but if necessary 5- or 6-inch studding may be used and the truss members may be increased in size accordingly. The faces of the truss members should be flush with the faces of the partition studding so as to receive lathing or sheathing.

The size of the truss members depends entirely upon the weight which the partition is called upon to carry. Besides its own weight, a partition is often called upon to carry one end of a set of floor joists and sometimes it supports columns which receive the whole weight of a story above. In any case, the pieces must be very strongly framed or spiked together, and sound material free from shakes and knot holes must be used.

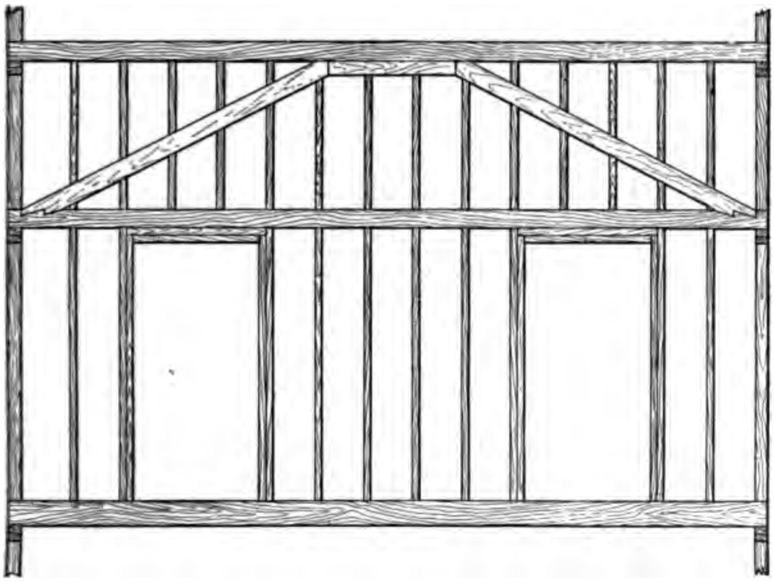


Fig. 216. Another Form of Trussed Partition

In Fig. 217 is shown another form of trussed partition spanning the space between two masonry walls. As will be seen this partition is constructed in a slightly different way from the others illustrated and described above. At the two sides of the opening, which is in this case in the center of the partition, are two uprights which are made considerably heavier and stronger than the ordinary studding of which the frame of the partition is composed. In the figure, the opening is marked *A*, and the uprights at the sides of the opening are marked *B B*. In the upright pieces shoulders are formed, as shown at *C* in the figure, and into the shoulders are fitted braces which go diagonally across the partition to the lower corners near the wall where they are notched into the lowest member of the trussed frame. These diagonal pieces are marked *D* in the figure, and the lowest member of the frame is marked *E*. The piece *E* goes across from wall to wall and should run well into each wall as shown, so as to obtain a good bearing on the masonry and there should be a bearing plate or template of some kind under each end of it, as shown in the figure at the points *F*, to distribute the weight of the partition over a large surface of the masonry. For this purpose a thin iron plate will answer very well, or a large flat stone may be used. The piece *E* strengthens the floor construction and helps support the partition; the joists *G* rest on top of the piece *E*, or are notched over it, and the flooring *H* rests on these joists.

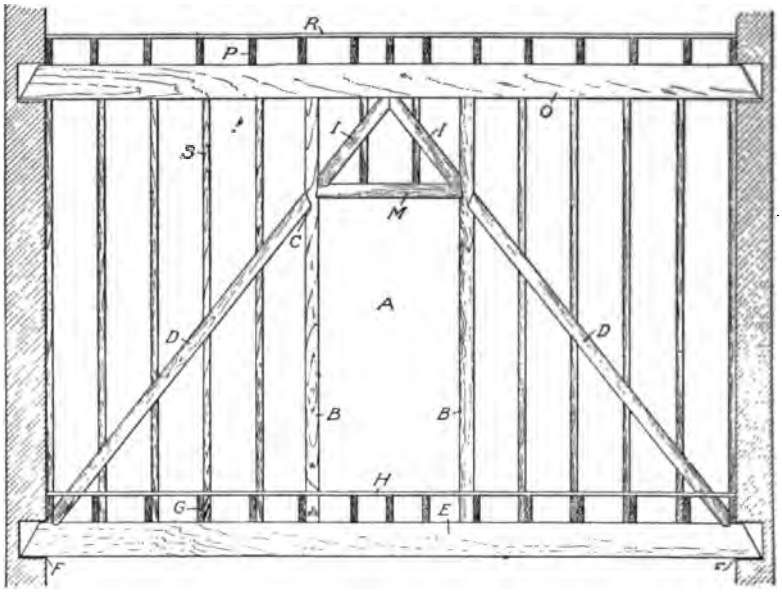


Fig. 217. Trussed Partition Spanning Space between Two Brick Walls

Above the door opening *A* there are two diagonal pieces *I* which come together at the top of the partition, forming a small truss over the opening and completing the trussing of the partition. The diagonal pieces *I* meet the uprights on each side of the door opening at the point where the horizontal piece *M* meets the uprights, and they should be notched into either one or the other or both. The topmost member of the trussed partition frame is marked *O* in the figure, and on top of it rest the joists of the floor above, which either rest directly on it or are notched over it according to circumstances. These joists are marked *P* in the figure. They support the flooring *R* of the floor above the partition. The main members of the partition frame are filled in with ordinary studding, 2×4 inches or 2×3 inches, spaced 1 foot or 16 inches apart. These studs are marked *S* in the figure.

Inclined and Bowled Floors. In any large room which is to be used as a lecture hall the floor should not be perfectly level throughout, but should be so constructed as to be higher at the back end of the room than it is at the front. The fall of such a floor from back to front should be not more than ¾ of an inch in 1 foot, and a fall of ½ an inch in 1 foot is much better. If the floor has a greater slope than this it becomes very noticeable when anyone attempts to walk over it.

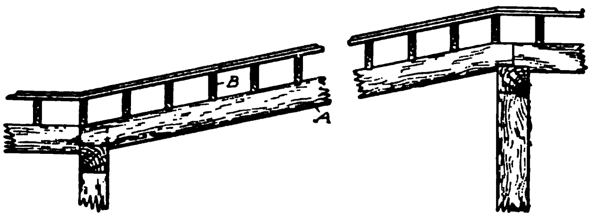


Fig. 218. Building an Inclined Floor

The simplest way to arrange for the slope is to construct what is known as an "inclined" floor, which rises steadily from front to back, so that a line drawn across it from side to side, parallel to the front or rear wall of the room, will be level from end to end. There are two methods of building an inclined floor, the difference between them being in the arrangement of the girders and floor joists. The two methods are shown in Figs. 218 and 219.

Fig. 218 shows the arrangement when it is necessary to have the girders run from the back to the front of the room, parallel to the slope of the floor. In this case the girders *A* are set up on an incline and the joists *B* resting on top of them are level from end to end. Each line of joists is at a different elevation from the lines of joists on each side of it. The floor laid on top of the joists will then have the required inclination. The slope of the girders must be the same as the slope required for the finished floor.

Fig. 219 shows the arrangement when it is desired that the girder shall run from side to side of the room, at right angles in the direction of the slope of the floor. The joists *A* will then be parallel to the direction of the slope, and are inclined to the horizontal, while the girders *B* are level from end to end. Each line of girders is at a different elevation from every other line of girders, and these elevations must be so adjusted that the joists resting on top of the girders will slope steadily from end to end.

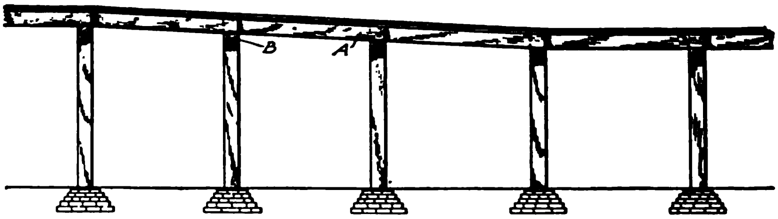


Fig. 219. Building Inclined Floor When Girders Run at Right Angles of Slope

When a simple inclined floor is employed, the seats must be arranged in straight rows, extending across the room from side to side, so that each line of seats may be level from end to end. This arrangement is not always desirable, however, and it is often much better to have the seats arranged in rings facing the speaker's platform. In this case a bowled floor must be built. A bowled floor is so constructed that an arc, drawn on the floor from a center in the front of the room, on or near the speaker's platform, will be perfectly level throughout its length. This means that the floor must pitch upward in all directions from the speaker's platform, or, in other words, it must be bowled. There are two methods of constructing a floor of this kind. The simplest way is to build first an ordinary inclined floor, which slopes from the front to the back of the room, and then to build up the bowled floor with furring pieces. This method should always be followed when it is necessary to keep the space beneath the lecture hall free from posts or columns.

The second method is to arrange girders, as shown in the framing plan of a bowled floor in Fig. 220. These girders *A* are tangent to concentric circles which have their center at the speaker's platform, and each line of girders is at a different elevation. The elevations of the different lines of girders are so adjusted that the floor joists *B* which rest on them, will slope steadily upward as they recede from the platform. The girders may be supported on posts beneath the floor of the hall, and if the space under the floor is not to be used for another room, this is a very good method to employ.

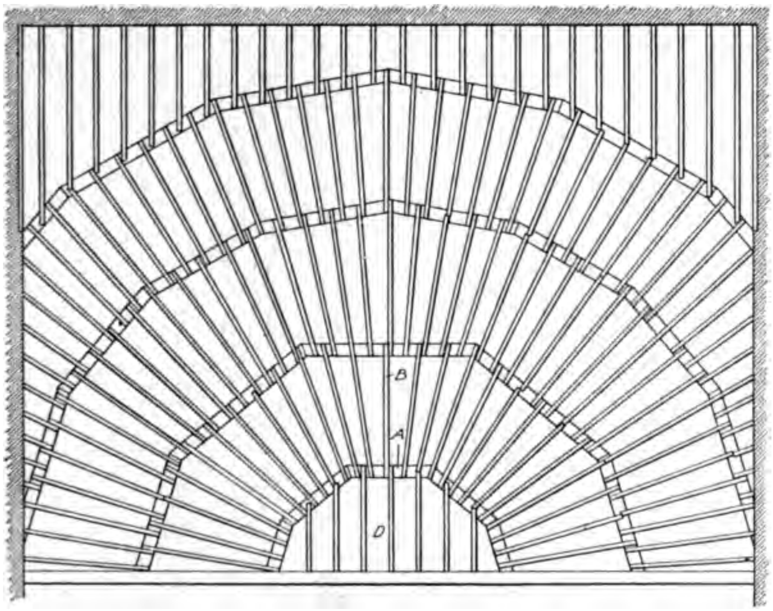


Fig. 220. Framing Plan of a Bowled Floor Showing Arrangement of Girders

Immediately around the platform there will be a space *D*, the floor of which will be level, and the slope will start several feet away from the platform.

If the floor is framed in this way it means that there will have to be a large number of posts in the space immediately beneath the floor, so many in fact as to make it practically impossible to make use of this space for another purpose. It would be necessary to put a post at each intersection of the girders which are arranged in concentric rings about the speaker's platform, so that the posts in the space below would also appear in rings parallel to each other and only a comparatively small distance apart. It is not possible to do away with absolutely all of these posts except as explained

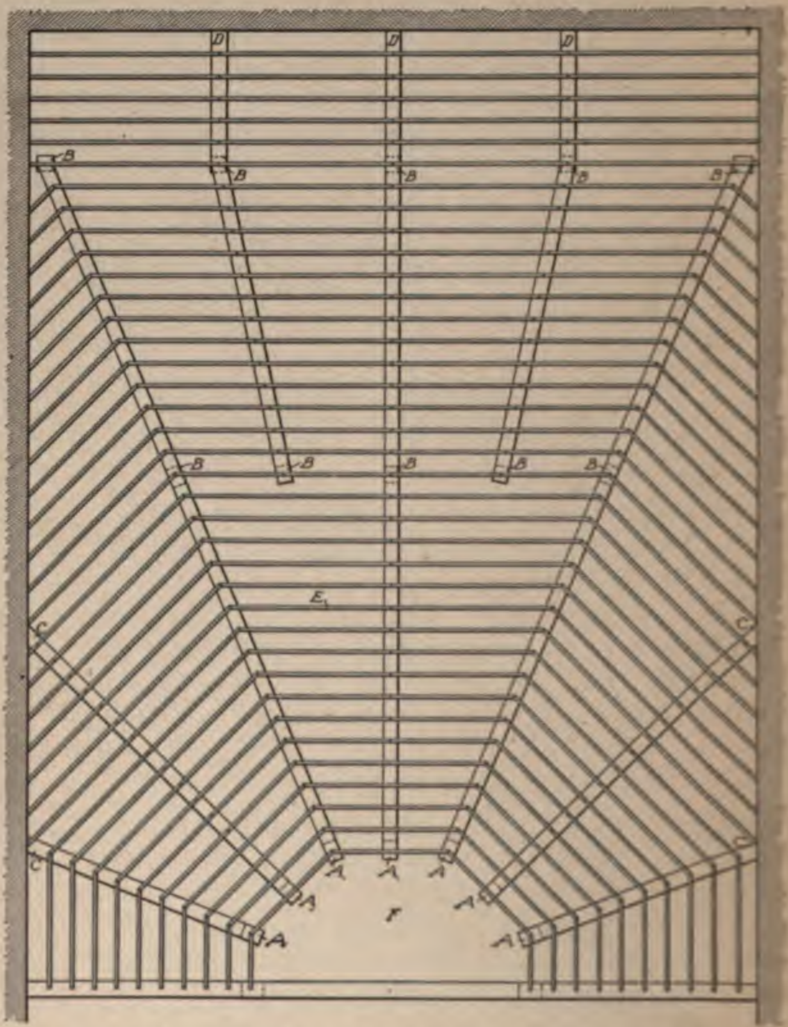
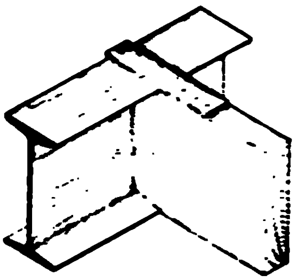


Fig. 221. Framing Plan for Bowled Floor of Longer Type than Fig. 220

above, by building up on top of a plain inclined floor surface, but it is possible to do away with a large number of them if necessary, as will be explained. In Fig. 221 suppose that the space marked *F* is the flat space at the front of the room which we wish to floor with a bowled floor. We can place posts around this space under the floor as shown at the points marked *A*, and some more posts farther back from the front as shown at the points marked *B*. Between each set of points marked *A* and *B* we can run girders, resting at the front end on the post *A*, and at the other end on the post *B*. Other girders can be run from the posts *A* to the wall as, for example, the girder *A C;* and others again may be run from the points *B* to the walls as, for example, the girders *B D*. These girders can all be inclined so as to slope evenly toward the front from all directions, so that points on all the girders at a given distance from the center of the room at the front wall will be at the same level. The framing formed by the girders may now be filled in by joisting *E*, and the flooring laid on top of the joisting so as to form a solid floor surface on which the seats may be placed. The floor surface thus formed will slope towards a point in the center of the front wall and all the seats will face the platform in concentric rings, each ring being level from end to end. In the space beneath the floor there will be only a comparatively small number of posts, arranged in such a way that the space can be utilized for rooms if desired. All the posts marked *B* will be in a straight line and can be covered by a partition, so that only the posts marked *A* will be troublesome, and these are clustered together at the front where they can be easily concealed. The room shown in Fig. 221 has been purposely made somewhat different from the room shown in Fig. 220. In Fig. 221 the room shown is longer than it is wide while in Fig. 220 the room shown is wider than it is long. This gives rise to a slight difference in the appearance of the framing, but the principle is the same in both cases, and the two methods of procedure apply equally well to both rooms.

Heavy Beams and Girders. For ordinary framed buildings there will be no difficulty in obtaining timbers large enough for every purpose, but in large structures, or in any building where heavy loads must be carried, it is often impossible to get a single piece which is strong enough to do the work. In this case it becomes necessary to use either a steel beam or a trussed girder of wood, or to build up a composite wood girder out of a number of single pieces fastened together in such a way that they will act like a single piece.

Steel beams are very often employed for girders when a single timber will not suffice, and although they are expensive, the saving in labor helps to offset the extra cost of the material.



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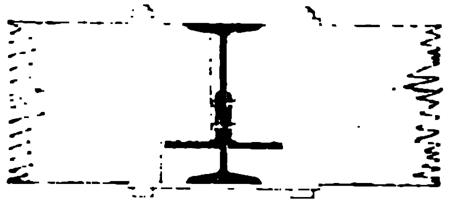
Wherever wood joists or girders come in contact with a steel beam they must be cut to fit against it. The steel shape most commonly employed is the I-beam and the wood members must be cut at the ends so as to fit between its flanges. This is shown in Fig. 222. The joist *B* is supported on the lower flange of the I-beam *C* and the strap *A* prevents it from falling away from the steel member. The strap is bolted or spiked to the wood beam and is bent over the top flange of the steel beam as shown. If two wood beams frame into the steel beam opposite each other, a straight strap may be used passing over the top of the steel beam and fastened to both the wood beams, thus holding them together. If a better support should be desired for the wood beam, an angle may be riveted to the web of the I-beam, as shown in Fig. 223, and the end of the wood joist may be supported on the angle. This is an expensive detail, however, and it is seldom necessary.



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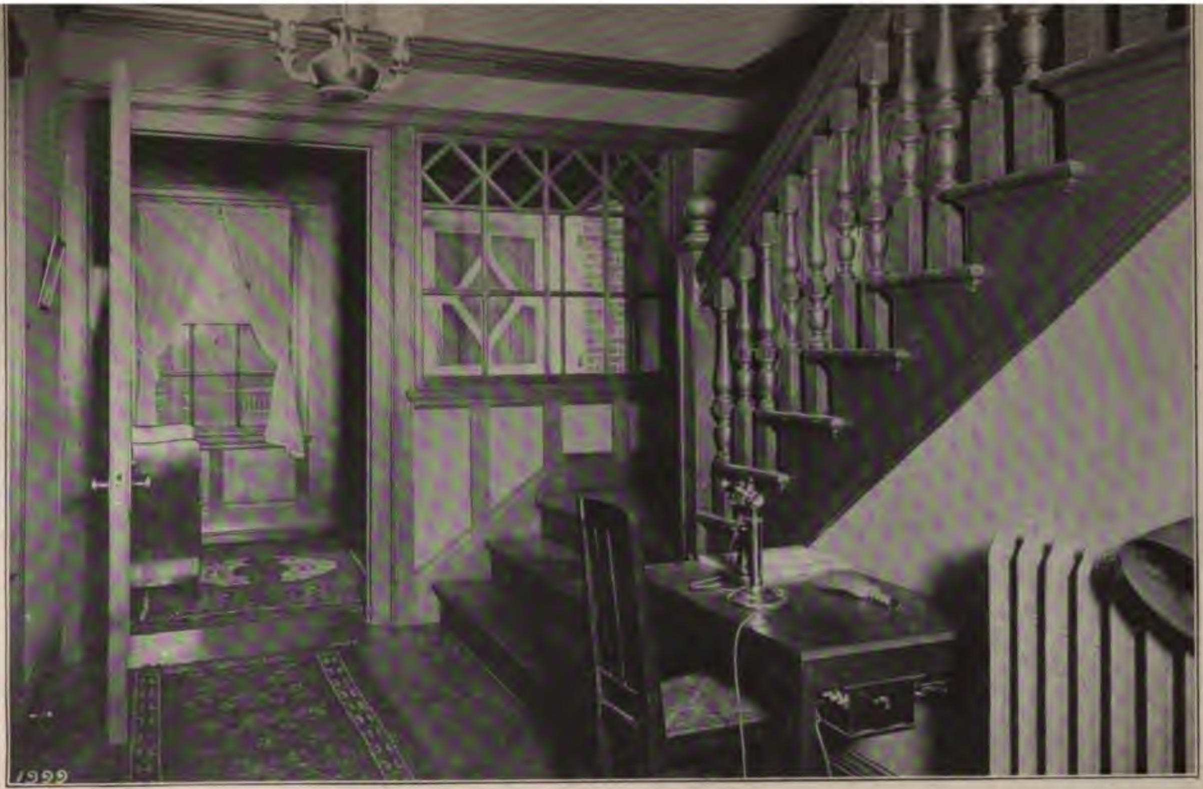
If a timber is not strong enough to carry its load, and if it is not desirable to replace it with a steel beam, it may be strengthened by trussing. There are two methods of trussing beams: by the addition of compression members above the beam, and by the addition of tension members below it. The first method should be employed whenever, for any reason, it is desired that there be no projection below the bottom of the beam itself. The second method is the one most



STAIR HALL IN RESIDENCE AT KENOSHA, WIS.
Pond & Pond, Architects, Chicago, Ill.
For Plan and Exterior, See Vol. III, Page 314.

In Fig. 231 is shown another form of girder with the parts notched, as shown, so as to lock together. This prevents them from slipping by each other. Bolts are employed to hold the parts together, so that the surfaces will always be in close contact. While this form of girder is very easily constructed, it has many disadvantages. A great deal of timber is wasted in cutting out the notches, as these must be deep enough to prevent crushing of the wood at the bearing surfaces, and thus the full strength of the timbers is not utilized. Moreover, it is apt to deflect a good deal, and its efficiency is not so great as that of other forms. On the whole it is inferior to the form previously described.

The compound beam which is almost universally considered the best is that shown in Fig. 232. This is known as a *keyed beam*, its characteristic feature being the use of *keys* to keep the parts from sliding on each other. The strength of a keyed beam has been found by actual experiment to be nearly ninety-five per cent of the strength of the solid timber, while the deflection when oak keys were used was only about one-quarter more than the deflection of the solid beam. By using keys of cast iron instead of wood this excess of deflection in the built-up girder can be reduced to a very small percentage. The keys should be made in two parts, each shaped like a wedge, as explained in connection with the keys for tension splices, and should be driven from opposite sides into the holes made to receive them, so as to fit tightly. They should be spaced from 8 to 16 inches apart, center to center, according to the size of the timbers, and should be spaced more closely near the ends of the beam than near the middle. In the center of the span there should be left a space of 4 or 5 feet without any keys.

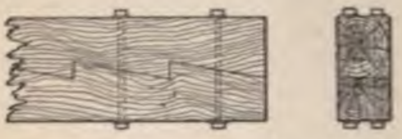


Fig. 231. Compound Girder with Notched Surfaces

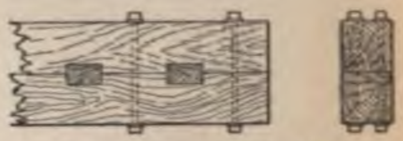


Fig. 232. Example of Keyed Beam

Balconies and Galleries. In churches and lecture halls it is almost always customary to have one or more balconies or galleries, extending sometimes around three sides of the main auditorium, commonly used, especially in warehouses, stables, and other buildings where the appearance is not an important consideration.

In Fig. 224 is shown a beam which is trussed by the first method with compression pieces *A* above the beam. All the parts are of wood excepting the rods *B*, which may be of wrought iron or steel. The beam itself is best made in two parts *E E* placed side by side, as shown in the section at *A*. This section is taken on the line *C D*. The depth of the girder may be varied to suit the conditions of each case. In general the deeper it is made the stronger it becomes, provided that the joists are made sufficiently strong. Usually girders of this kind are made shallow enough so that the compression member will be contained in the thickness of the floor and will not project above it. A slight projection below the ceiling is not a serious disadvantage. The floor joists *F* may be supported on the pieces *E*, as shown at *A*.

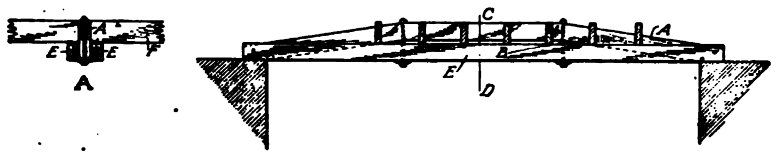


Fig. 224. Trussing a Girder by Use of Compression Members

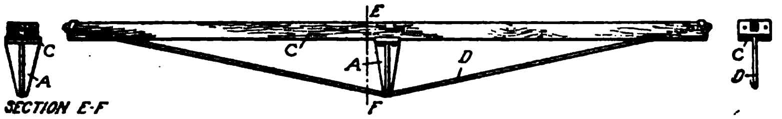


Fig. 225. Trussing Girder by Use of Tension Member—King-Post Trussed Beam

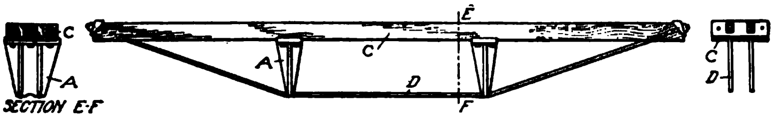


Fig. 226. Trussed Girder with Two Struts—Queen-Post Trussed Beam

In Figs. 225 and 226 are shown examples of girders which are trussed by the second method with tension rods *D* below beam. These rods are of wrought iron or steel, and the struts *A* are of cast iron. The struts may be made of wood if they are short, or if the loads to be carried are not heavy. Sometimes the girders are made very shallow and the struts *A* are then merely wood blocks placed between the beams *C* and the rod *D* to keep them apart. The girder shown in Fig. 225 is known as a king-post trussed beam, while the one shown in Fig. 226, with two struts instead of one, is known as a queen-post trussed beam. The beam itself, *C*, may be made in two or three pieces side by side with the rods and the struts fitting in between them, or it may be a single piece, and the rods may be made in pairs, passing one on each side of the beam. The struts bear against the bottom of the beam, being fastened to it by bolts or spikes, as shown in the illustrations, so that they will not slip sidewise.

It sometimes happens that a heavy girder is required in a situation where trussing can not be resorted to, and where steel beams can not be readily obtained. In this case the only resource is to build up a compound beam from two or more single pieces. A girder of this kind can be constructed without much difficulty, and can be so put together as to be able to carry from eighty to ninety per cent of the load which a solid piece of the same dimensions will bear. There are many ways of combining the single timbers to form compound beams, some of the most common of which will be described.

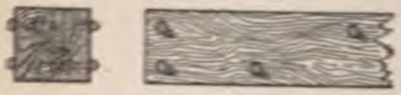


Fig. 227. Construction of Compound Beam

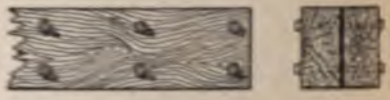


Fig. 228. Flitch-Plate Girder

The most simple combination is that shown in Fig. 227. The two single timbers are bolted together side by side, with sometimes a small space between them. The bolts should be spaced about 2 feet apart and staggered as shown, so that two will not come side by side. Usually bolts three-quarters of an inch in diameter are used.

In Fig. 228 is shown a modification of this girder known as a "flitch-plate" girder. It has a plate of wrought iron or steel, inserted between the two timbers, and the whole is held firmly together by bolts. The size of the plate should be in proportion to the size of the timbers, so as to make the most economical combination. In general the thickness of the iron plate should be about one-twelfth of the combined thickness of the timbers.

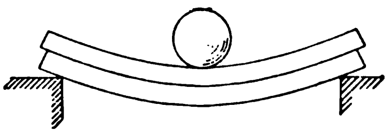


Fig. 229. Action of Compound Girder Under Tension

If we have two pieces of timber out of which we wish to make a compound girder, it is always possible to get a stronger combination by placing them one on top of the other, than by placing them side by side. This is because the strength of a beam varies as the square of its depth, but only directly as its width. For this reason most compound girders are composed of single pieces placed one above the other. The tendency is for each piece to bend independently, and for the two parts to slide by each other, as shown in Fig. 229. This tendency must be overcome and the parts so fastened together that they will act like a single piece. There are several methods in common use by which this object is accomplished.

Fig. 230 shows the most common method of building up a compound girder. The timbers are placed together, as shown, and narrow strips of wood are nailed firmly to both parts. The strips are placed close against each other and have a slope of about forty-five degrees, sloping in opposite directions, however, on opposite sides of the girder. It has been claimed that a built-up girder of this kind has strength ninety-five per cent as great as the strength of a solid piece of the same size but it is very doubtful whether this is true in most cases. Actual tests seem to indicate that such girders have an efficiency of only about seventy-five per cent. They usually fail by the splitting of the side strips, or the pulling out and bending of the nails, but seldom by the breaking of the main pieces. It is, therefore, essential that the strips should be very securely nailed to each of the parts which make up the girder, and that they should also be carefully selected so that only those pieces which are free from all defects may be used. These girders are liable to considerable deflection, and should not be used in situations where such deflection would be harmful.

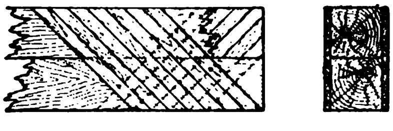


Fig. 230. Method of Building up Compound Girder

These pieces are made double or in pairs, as shown in the end view *M*, and are separated a little so as to allow the hanger rod to pass between the two pieces as shown. *F* is the hanger, which is a round or a square rod about 1 inch in diameter. The pieces *A* should continue a short distance beyond the point where the rod passes between them, and the ends may be cut to any shape desired in order to give them a pleasing appearance, as shown. They should be spaced 7 or 8 feet apart, and on top of them may be placed ordinary joists of small size, marked *B* in the figure, which are spaced about 12 or 14 inches apart. On top of the joists *B* is laid a rough floor, marked *C* in the figure, and above this again is laid the finished flooring of the balcony *D*. A joist should be placed on each side of the hanger *F*, as shown at *N* and *O*, and against the joist marked *O* should be nailed the finished fascia piece *G*. This finished piece *G* should run up past the under boarding *C* and stop against the under side of the finished top flooring of the balcony. There should be a bed molding *H* at the juncture between the piece *G* and the top flooring *D*, so as to cover and conceal the joint.

The hanger *F* should pass between the pieces *A*, and should be threaded at the bottom so as to receive a nut *J* by which it may be tightened up. There should be a washer *I* consisting of a square plate of iron between the nut *J* and the wood of the pieces *A*, so the wood will not be crushed and so that the nut will not sink into the wood.

The under side of the balcony seen from the floor of the main hall may be treated in any one of a variety of ways. The joists may be furred and lathed and plastered on the under side so that a plastered surface will be presented, or the under side of the joists may be covered with sheathing, V-jointed or beaded, or the joists may be more carefully finished and left exposed to view from below.

TIMBER TRUSSES

In the discussion of roofs and roof framing which has already been given here, only those roofs have been considered which were of so short a span that they could easily be covered with a framework of ordinary rafters, spaced from 1 to 2 feet apart, between centers, but it is very often necessary to build roofs of larger span, for which ordinary rafters, even if supported by dwarf walls and collar beams, are not sufficiently strong. In this case a different method of framing must be employed.

Instead of a number of rafters spaced fairly close together, and all of equal strength, we will have a few heavy "trusses," placed at intervals of 10 or more feet, and spanning the entire distance between the two side walls. On top of the trusses are laid "purlins," running parallel to the walls, which in their turn support the common rafters, running perpendicular to the side walls, as in the case of simple rafters in an ordinary roof: There may be one or more purlins in each slope of the roof, depending upon the size of the span, since the purlins must be spaced near enough together so that a small rafter can span the distance between them. Usually there will be a purlin at each joint of the truss and the joints will be determined by the safe span for the rafters.

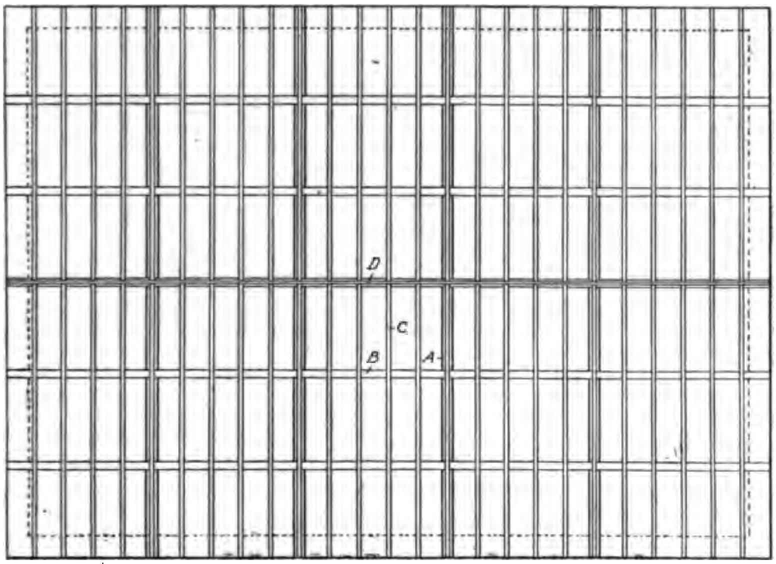


Fig. 236. Roof Plan Showing Use of Heavy Trussed Purlins and Common Rafters

This arrangement is shown in plan in Fig. 236, in which *A* are trusses, *B* are the purlins, *C* are the common rafters, and *D* is the ridge.

There are many different kinds of trusses in common use for various kinds of buildings, which differ from each other chiefly in the arrangement of the tension and compression pieces of which every truss is built up. Some trusses are built entirely of timber, while in others timber is employed only for the compression pieces, and wrought iron and steel for the tension pieces.

King-Post Truss. Fig. 237 shows what is known as a *king-post truss*. Its distinguishing feature is the member *A* called a *king-post*, *B* are the purlins, and *E* are the rafters resting on them. As will be seen by a study of the figure, the members of the truss are so arranged as to divide it up into a series of triangles, or rather into a series of triangular open spaces, bounded by the various members of the framework. This is an essential characteristic of a good and efficient truss. Such a framework may fail by overloading in such a way as to be crushed or broken, but it can not be distorted, that is, none of the triangular spaces can change their shape without some member of the truss being either lengthened or shortened, which means that some member of the framework must fail by either tension or compression before the truss can be distorted, or can fail to carry its load by reason of the failure of the joints. This principle does not hold true for a framework composed of spaces in the form of rectangles, of which the members of the framework form the sides, because it is possible for a rectangular framework to become distorted without any side being either lengthened or shortened, by the simple failure of some of the joints and the movement of the members around the joints. For this reason the first thing to con-

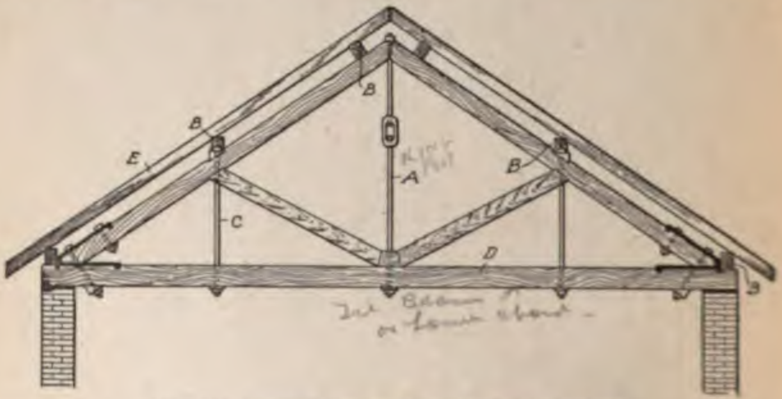


Fig. 237. Section Showing Design of King-Post Truss

sider in designing a truss is the arrangement of the members and the position of the joints so all of the open spaces will be in the form of triangles.

In Fig. 237 are shown two different methods of placing the purlins. As will be readily seen, some of them are set so that their longer dimension in cross section is vertical, while others are set so that their longer dimension is at right angles to the rafters. Both of these methods are commonly employed. The tension members *C* are merely for the support of the lower chord or *tie-beam D*.

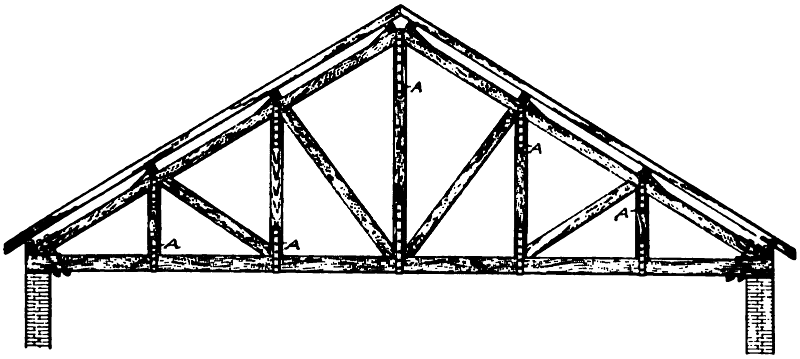


Fig. 238. Section Showing Design of King-Post Truss for Wide Span

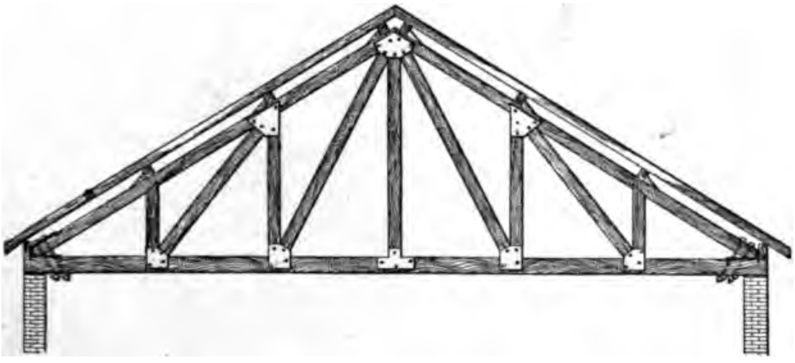


Fig. 239. Section Showing Design of Trussed Roof Using Iron Castings at Joints

Fig. 238 shows a truss of the same general form as the one shown in Fig. 237, but of larger span. This truss is of such a span and has its joints and purlins arranged in such a way that it is similar to the trusses shown in plan in Fig. 236 and there marked *A*. In this truss also the vertical members are not iron rods, as in Fig. 237, but are composed of timber. The stresses in these members are, however, still tension stresses just the same as in Fig. 237, and for this reason it is a common practice to fasten them to the chords of the truss by means of iron straps, as shown at the points marked *A* in Fig. 238. In other respects this truss is constructed in a manner similar to that in which the truss shown in Fig. 237 is built.

Fig. 239 shows a truss with the diagonal members running in a direction opposite to that in which run the diagonal members in the two trusses previously shown. This figure also illustrates the practice of placing an iron casting at each joint of the truss to receive the members which come together at that joint. This arrangement is, however, an expensive one on account of the castings, and it is doubtful if the advantage gained by the use of them is sufficient to warrant the additional cost. Usually the castings can not be kept in stock and must be made to order for each truss.

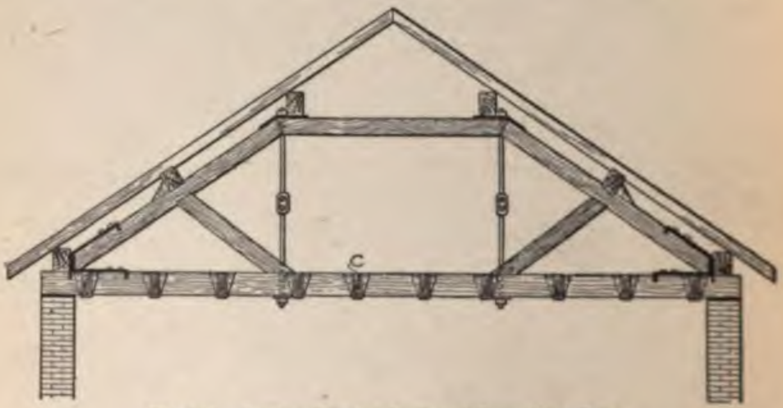


Fig. 240. Section Showing Design of Queen-Post Truss

Queen-Post Truss. Fig. 240 shows a modification of the king-post truss, which is called the queen-post truss. Here there are two queen-posts instead of the single king-post. The queen-post truss is somewhat more popular in building work than is the king-post truss, but both are frequently employed in halls, warehouses, and stables, where an ornamental truss is not required, and also in churches and audience rooms, where they are to be concealed by other finish. Fig. 240 also shows how a floor or ceiling may be supported on the lower chord or *tie-beam* of the truss. The joists *C* are hung from the chord by means of stirrup irons or patent hangers. This arrangement makes the tie-beam act as a beam as well as a tie and in this case it must be made sufficiently strong to carry the load from the joists without sagging.

The queen-post truss, as will be seen, is not entirely composed of triangles, the center panel being in the form of a rectangle. In most cases this is not a serious disadvantage, since, when the truss is uniformly loaded, as it would be if it were an ordinary roof truss, there is no tendency to distort the center panel. It is almost always better, however, to introduce an additional diagonal member into this panel so as to divide it into two triangles. This obviates any danger of distortion of this panel.

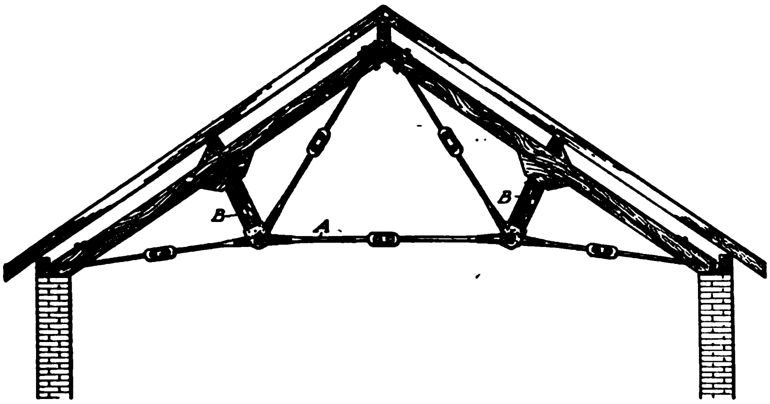


Fig. 241. Section Showing Design of a Fink Truss

Fink Truss. In Fig. 241 is shown a Fink truss, which is a very popular form, especially for trusses built of steel. It has neither king-post nor queen-posts, and the tie-beam *A* is of iron or steel instead of timber. This is a simple and cheap form of truss for any situation where there is no floor or ceiling to be carried by the lower chord. The struts *B* may be of wood or of cast iron. It will be seen that the truss consists essentially of two trussed rafters set up against each other, with a tie-rod *A* to take up the horizontal thrust.

Open Timber Trusses. Besides the forms of trusses described above, there are other forms which are used in churches and chapels, as well as in halls where open timber work is required, and where the trusses will not be concealed by other finish, but will be made ornamental in themselves. Among these the most common forms are the so-called scissors truss and the hammer beam truss.

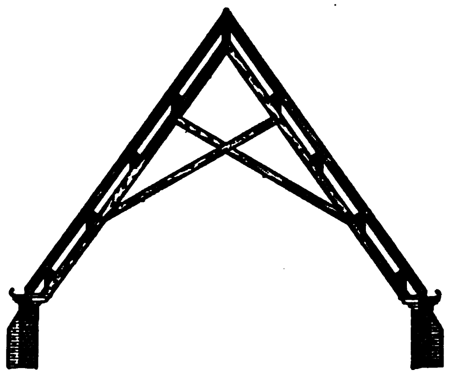


Fig. 242. Design of a Scissors Truss

Scissors Truss. The scissors truss is shown in Fig. 242. It has no tie-beam and, therefore, it will exert considerable thrust on the walls of the building, which thrust must be taken care of by buttresses built on the outside of the walls. This is perhaps the most simple form of truss which can be used when an open timber truss is required. All the parts are of wood. If desired, an iron tie rod may be inserted between the two wall bearings of the truss, so as to elimi-

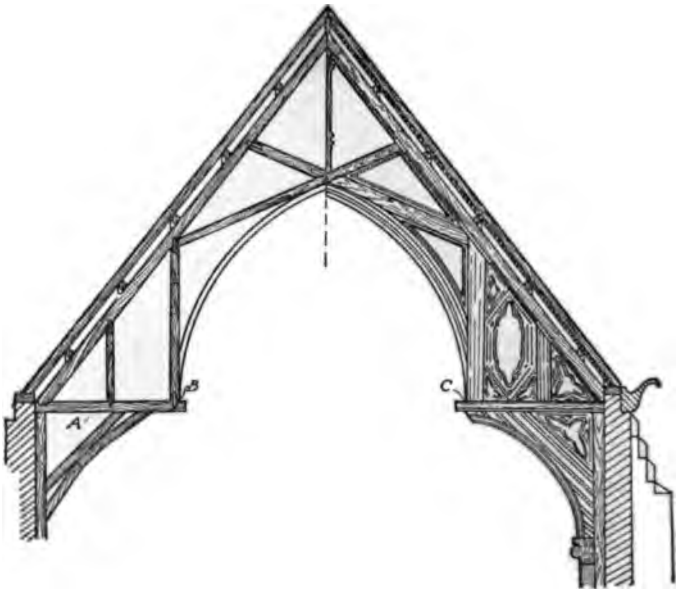


Fig. 243. Hammer Beam Truss Used Particularly for Churches

nate the thrust on the walls, and this rod need not detract seriously from the appearance of the open timber work.

Hammer Beam Truss. A very popular form of truss for use in churches is the hammer beam truss mentioned above. This is shown in Fig. 243. On the left is shown the framework for the truss, while on the right is shown the way in which it may be finished. Its characteristic feature is the hammer beam *A*. The sizes of the pieces can only be determined by calculation or experience, and depend entirely upon the span of the truss and the loads to be carried, which are different for different locations. It is common practice to insert a tie rod between the points *B* and *C* to take up the thrust which would otherwise come on the walls. All parts of the framework must be securely bolted or spiked together so as to give a strong, rigid foundation for the decoration, which should be regarded merely as decoration and should not be considered as strengthening the truss in any way.

Truss Details. There are several methods of supporting the purlins on wood trusses, but the method illustrated in Fig. 244 is one of the best as well as the most frequently employed. A block of wood *A* is set up against the lower side of the purlin, and prevents it from turning about the corner *B*, which it has a tendency to do. The block is set into the chord of the truss to a depth sufficient to keep the purlin from sliding downward as it receives the weight from the rafters *E*. This figure also shows the most simple method of framing a strut into the chord of a truss. The strut *C* is set into the chord *D* far enough to hold the strut in place. If it is perpendicular to the chord, it need not be so set into it, if the pieces are well nailed together, because in this case there is no tendency for the strut to slide along the chord. Care should be taken not to weaken the chord too much in cutting these mortises.

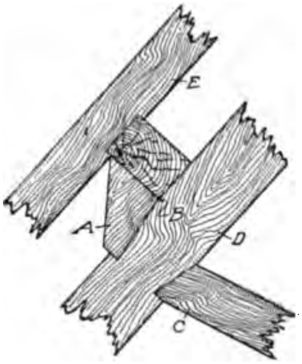


Fig. 244. Method of Supporting the Purlins on Wood Trusses

In Fig. 245 are shown the most common methods of forming the joint between the top chord and the tie-beam of a truss. The connection shown at *A* depends upon the bolts for its strength, while that shown at *B* depends upon the wrought-iron straps *E*, which are bent so as to engage notches cut in the tie-beam *F*. The piece *C* is very often added beneath the tie-beam, at the bearing, to strengthen it at this point, where the beam is subject to considerable bending stress. The block *D* is merely for filling and to protect the bolts where they pass between the chord and the tie-beam. It may be omitted in many cases. The plate *G* is placed between the nuts or bolt heads and the wood to prevent the crushing of the latter. Washers should be used with all bolts for this purpose.

Fig. 246 shows how the joint at the center of the tie-beam of a king-post truss, or any joint between two struts, may be formed.

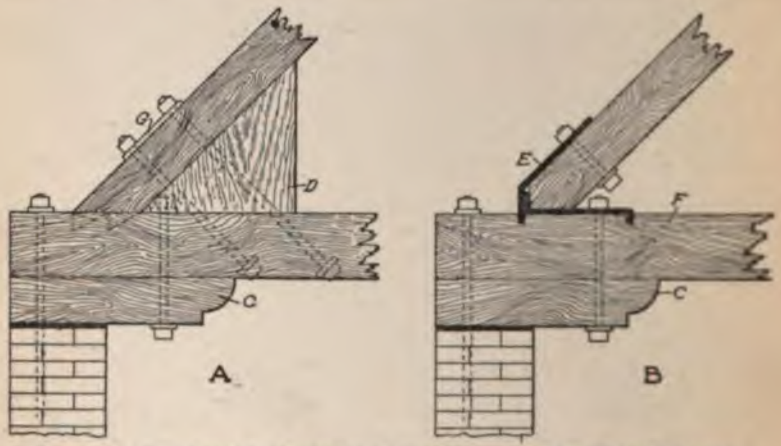


Fig. 245. Two Methods of Forming a Joint between Both Chord and Tie-Beam of a Truss

The tie-beam is shown at *A*, and *B* are the struts. The blocks *C*, set between the struts, receive the thrust from them. They should be notched into the tie-beam *A* deep enough to take care of any inequality between the thrusts from the two struts, which have a tendency to balance each other. The block is often made of cast iron. It may be omitted altogether, in which case the struts will come close together and bear against each other. The rod *D* is the king-post which supports the tie-beam *A* at this point. It is often made of wood and sometimes the struts *B* are framed into it instead of being framed into the tie-beam *A*.

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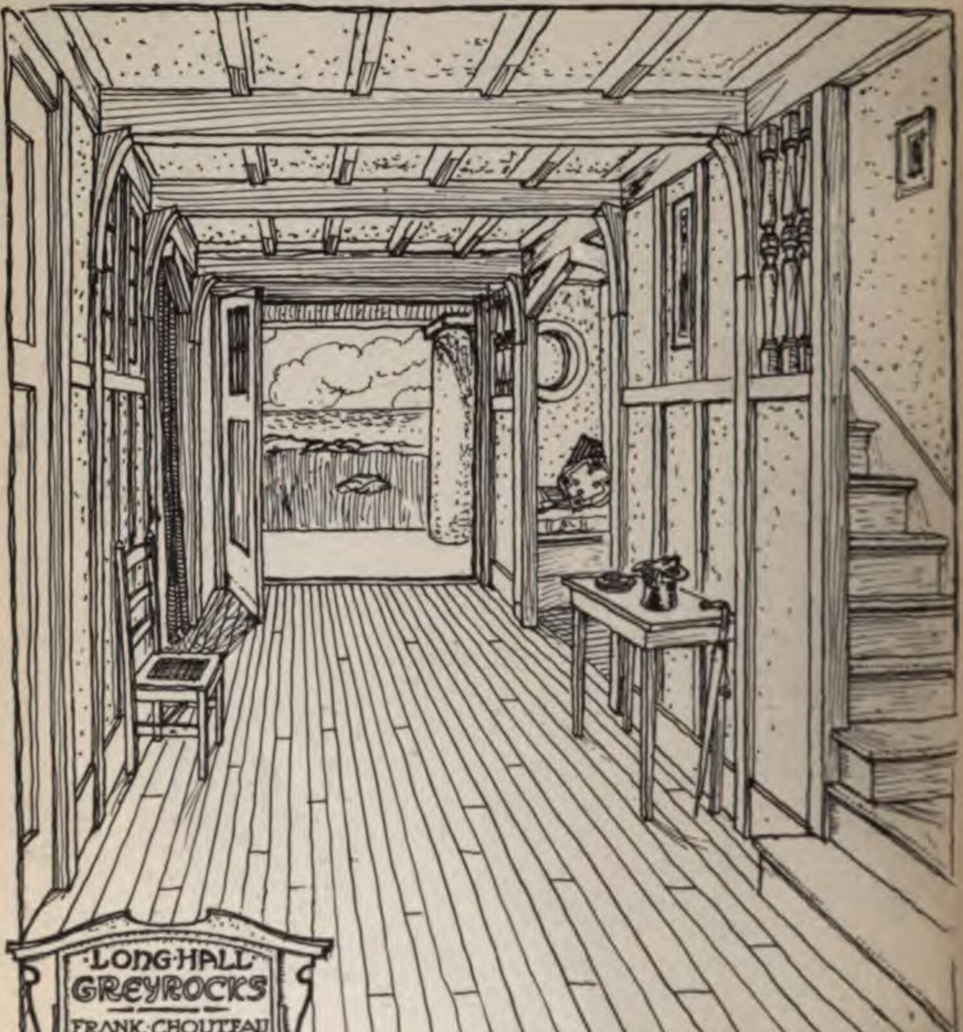
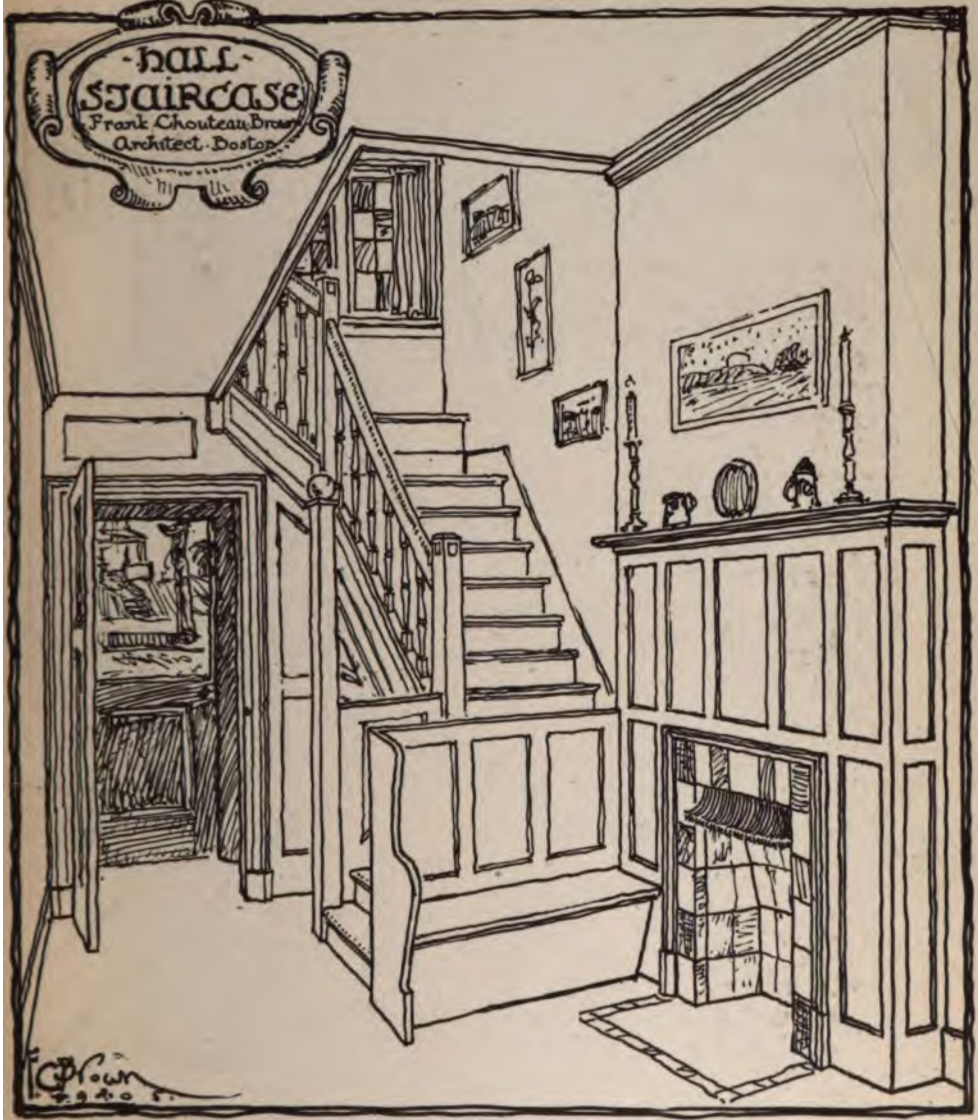


HALL AND PARTIALLY ENCLOSED STAIRCASE IN LONG HALL, GREYROCKS, ROCKPORT, MASS.

Frank Chouteau Brown, Architect, Boston, Mass.
For Plans and Exteriors, See Vol. I, Pages 272, 282, and 299.



HALL AND STAIRCASE IN HOUSE AT WOLLASTON, MASS.
Frank Chouteau Brown, Architect

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Fig. 247 shows a form of connection for the peak of a truss, where the two top chords or principal rafters come together. The plate *A* acts as a tie to keep these members in place, as does the bent plate *B*, also. The plate *B*, moreover, prevents the crushing of the timber by the nut of the king-post tie rod. The purlin *C* supports the rafters and is hollowed out at the bottom to admit the nut *D*. The two principal rafters bear against each other and must be cut so that the bearing area between them will be sufficient to prevent the crushing of the timber. In light trusses the king-post *E* is often made of wood and is carried up between the principal rafters so that these members bear against it on each side. If this construction is adopted it must be remembered that the post is a tension member, and is held up by the principal rafters, and these pieces must be mortised into it in such a way as to accomplish this result.

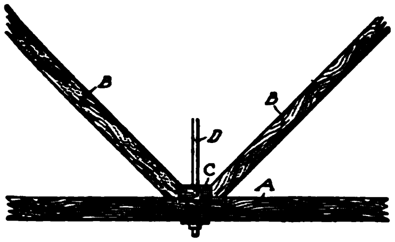

Fig. 246. Method of Forming Joint at Center of Tie-Beam in King-Post Truss

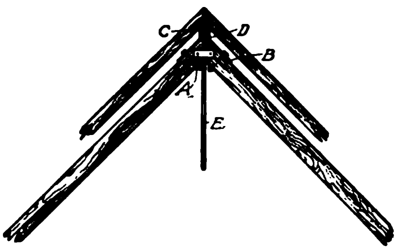

Fig. 247. Construction of the Peak Connection of a Truss

There are a great many different ways of arranging the details for wood trusses, each case usually requiring details peculiar to itself and unlike those for any other case. There are, therefore, no hard and fast rules which can be laid down to govern the design of these connections. A perfect understanding of the action of each piece and its relation to all of the other pieces is necessary in order to insure an economical and appropriate design. The aim should always be to arrange the details so that there will be as little cutting of the pieces as possible, and so that the stresses may pass from one piece to another without overstraining any part of the truss.

TOWERS AND STEEPLES

Towers are a very common feature in building construction, ranging in size from the small cupola used on barns to the high tapering spire which is the distinguishing mark of churches.

They have roofs of various shapes, some in the form of pyramids, with four, eight, or twelve sides, some of conical form, and others bell-shaped or having a slightly concave surface.

The construction of all these forms of towers is much the same, consisting of an arrangement of posts and braces, which becomes more elaborate as the tower or steeple becomes larger. The bracing is the most important consideration, because the towers will be exposed to the full force of the wind and must be designed to resist great strain.

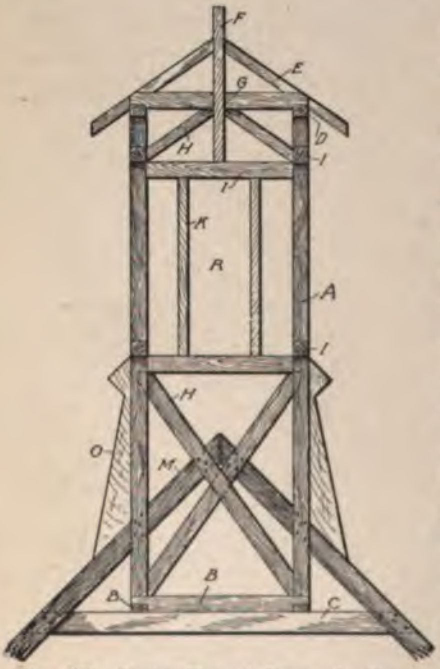

Fig. 248. Section Through Frame of a Simple Cupola

Cupola. Fig. 248 shows a section through the frame of a simple cupola. It has posts *A* at each corner, which rest at the bottom on the sills *B*. The sills are supported on extra heavy collar beams *C*, which are very securely spiked to the rafters of the main roof *M*. The corner posts extend clear up to the main plate *D*, which supports the rafters *E* of the cupola. There are hip rafters at the corner of the roof, which bear at the top against a piece *F* placed in the center of the roof. This scantling extends above the roof surface far enough to receive some kind of metal finial which forms the finish at the extreme top of the cupola; and at the bottom it is firmly fastened to the tie *G*, which is cut in between the plates. The braces *H* stiffen the frames against the wind. Girts *I* are cut in between the corner posts and form the top and bottom of the slat frame opening *R*, besides tying the posts together. The sides of the opening for the slat frame are formed by the vertical studs *K*. The rafters of the main roof *M* are placed close up against the corner posts on the outside, and the posts may be spiked to them. The pieces *O* are of plank 2 inches thick, and are simply furring pieces placed at intervals of 1½ to 2 feet all around the cupola to give the desired shape to the bottom part. The size of the pieces will depend on the size of the cupola. The posts may be 4×4 inches or 6×6 inches, and the braces, girts, and intermediate studding may be 3×4 inches or 4×6 inches.

Miscellaneous Towers. Other towers are framed in a manner similar to that described for a cupola. There is always a base or *drum*, with posts at the corners and with the walls filled in with studding, which supports a plate at the top. The rafters forming the tower roof rest at the foot on this plate, and at the top they bear against a piece of scantling which is carried down into the body of the tower for a considerable distance and is there fastened to a tie passing between rafters on opposite sides. This is shown in Fig. 249. The tie *A* is securely nailed to the rafters at each end, and to a post in the middle. The post is cut so as to have as many faces as the roof has sides, four for a square hip roof, eight for an octagon roof, and so on. Each face receives one of the hip rafters and the intermediate rafters are framed in between them. If the roof is conical or bell shape, as shown in the figure, the post at the top may be cylindrical in form. Although the roof shown is bell shaped the rafters are not cut to fit the curve. They are made straight and are filled out by furring pieces *B*. Pieces of plank *C* are cut in between the furring pieces, as shown, so as to give a nailing for the boarding, and they are cut to the shape of segments of circles, so as to form complete circles around the tower when they have been put in place. If a tower of this shape is to be built, having a number of faces and hips, the curve of the hip rafters will not be the same as the curve shown by a section through one of the faces of the tower. In order to find the true curve for the hip rafter, the same method is followed

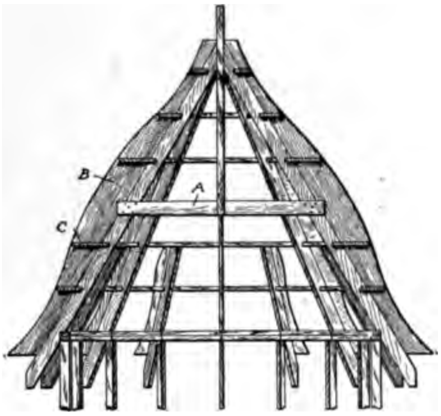

Fig. 249. Section Showing Frame Construction of Small Tower

as was explained for hip rafters in an ogee roof over a bay window, using the principle that any line drawn in the roof surface parallel to the plate is horizontal throughout its length. By this means any number of points in the curve of the hip rafter may be obtained and the curve for the hip may be drawn through them. Thus a pattern for the hip rafter may be obtained.

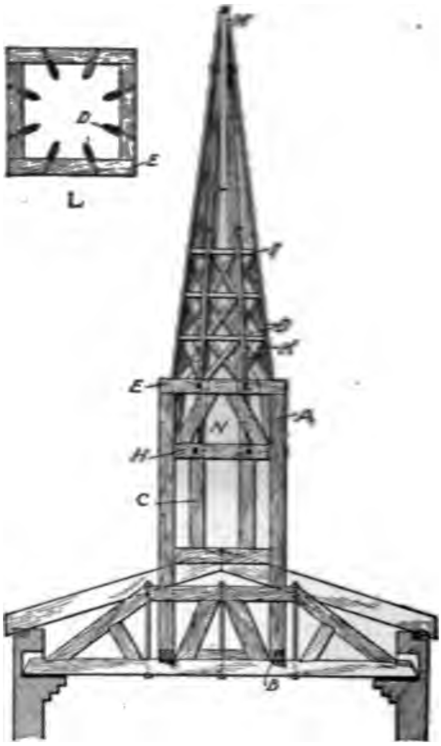

Fig. 250. Section Showing Contruction of Church Spire

Church Spire. Fig. 250 shows the method of framing a church spire, or other high tapering tower. The base of the drum *N* is square and is supported by the posts *A*, one at each corner, which rest on the sills *B*. The sills are supported by the roof trusses of the main roof. The corner posts extend the full height of the drum and are strongly braced in all four faces, with intermediate vertical studding *C* between them to form the framework for these faces. The spire itself may rest on top of this square drum or there may be another eight- or twelve-sided drum constructed on the top of the first drum, on which the spire may rest. This depends upon the design of the spire. The hip rafters *D* do not rest directly on top of the drum, however, as this arrangement would not give sufficient anchorage for the spire. They are made so as to pass close inside the plate *E* at the top of the drum and are securely bolted to this plate with strong bolts. This is shown at *L*, which is a plan of the top of the drum, showing the hip rafters in place. The plate is shown at *E*, and the hip rafters at *D*. The rafters extend down into the body of the drum as far as the girts *H* (shown in the elevation) to which they are again securely spiked or bolted, being cut out at the foot so as to fit against the girt. In this way a strong anchorage for the spire is obtained.

Horizontal pieces *I* are cut in between the hip rafters at intervals throughout the height of the spire, braces *K*, halved together at the center where they cross each other, are firmly nailed to the rafters at each end. These braces are needed only in lofty spires, which are likely to be exposed to high winds. At the top the hip rafters bear against a post *M*, the same as in the other towers. If a conical spire is called for in the design, the horizontal pieces *I* must be cut to the shape of segments of circles, and in this case the rafters are no longer hip rafters. The horizontal pieces *I* will receive the boarding, which will form a smooth conical surface.

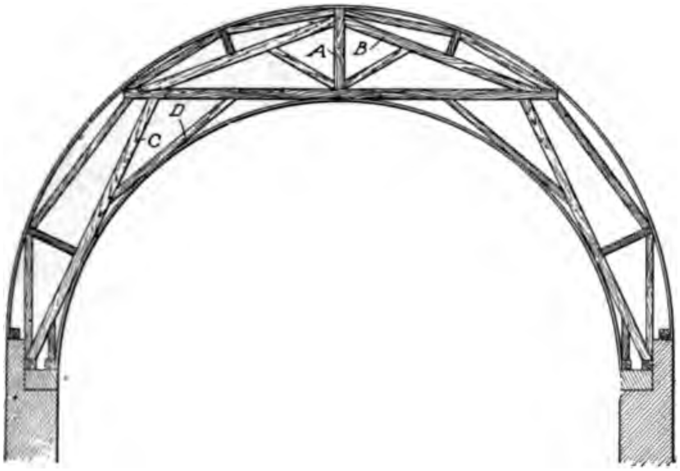

Fig. 251. Section Showing Frame Construction of a Dome

The spire above the drum is usually framed on the ground before being raised to its final position. It then may be raised part way and supported by temporary staging while the top is finished and painted, after which it may be placed in position on the top of the drum.

Domes. Timber domes have been built over many famous buildings, among which may be mentioned St. Paul's Cathedral at London, and the Hotel Des Invalides at Paris. While these structures are domical in shape they are not, strictly speaking, domes, because they do not depend for support upon the same principle which is implied in the construction of a dome. They are, correctly speaking, arrangements of trusses of such a shape as to give the required domical form to the exterior of the roof.

Fig. 251 shows such a truss supported at either end on a masonry wall. Fig. 252, which is a plan of the framing of this roof, shows how the sections or bents may be arranged. There are two complete bents, *A B* and *C D*, like the one shown in the elevation, Fig. 251, which intersect each other at the center. A king-post *A* in the elevation is common to both bents and the tie-beams *B* are halved together where they cross. These two bents divide the roof surface into four quarters, which are filled in by shorter ribs, as indicated in the plan, Fig. 252. The posts *C*, in Fig. 251, carry all the weight of the roof to the walls and are braced by means of the pieces *D*.

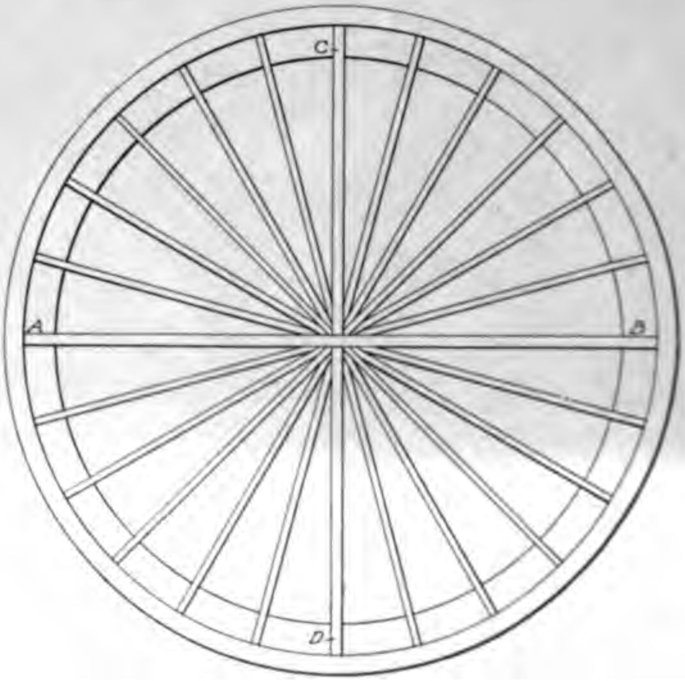

Fig. 252. Plan of Framing for Dome Shown in Section in Fig. 251

The rounded shape is given to the exterior and interior of the bent by pieces of plank bent into position as shown. The whole is covered with boarding which is cut to a special shape so that it can be bent into place. The methods of applying the boarding to domical roofs will be explained in connection with other rough boarding.

The arrangement of trusses described above is suitable for a plain domical roof without a lantern or cupola on top, but very frequently this feature is present in the design, and the roof must be framed to allow for it. There are several different ways of arranging the trusses so as to leave an opening in the center of the roof for the lantern. Fig. 253 shows a very good arrangement. Four trusses *A* span the entire distance between the walls, and are placed as shown in the figure, so as to leave the opening *B* in the center. Four half trusses *C* are inserted between them, as shown, and eight shorter ribs *D* are employed to fill in the rest of the space.

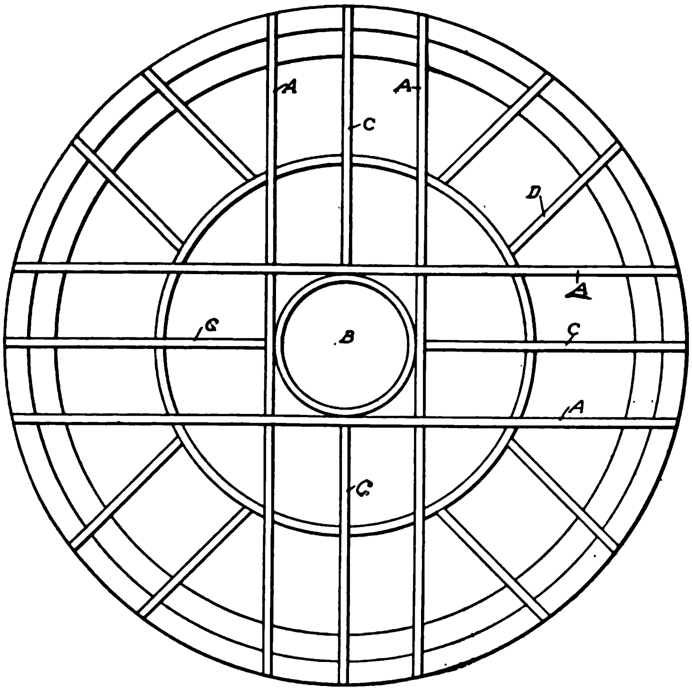

Fig. 253. Framing Plan for Dome Having Cupola

Fig. 254 shows another arrangement, providing for a lantern at the center. There are a number of ribs *A*, twelve in number, in the figure, all radiating from the center where there is a circular opening for the lantern or cupola. In Fig. 255 is shown a section through a domical roof framed in this way, showing an elevation of one of the ribs. The rib is so constructed as to be entirely contained in the restricted space between the lines of the exterior and interior of the roof.

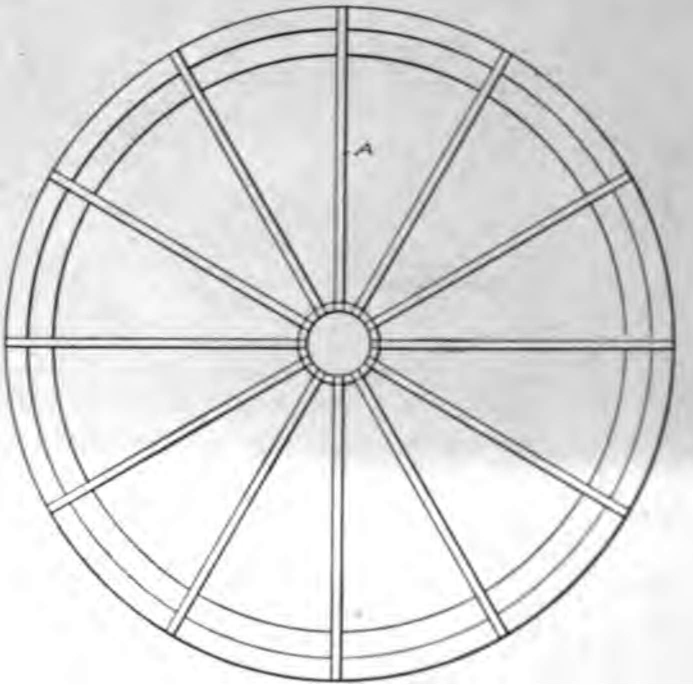

Fig. 254. Framing Plan for Dome Having Lantern at Center

Pendentives. In the preceding paragraphs we have considered the subject of domical roofs covering buildings of circular plan, which is the simplest possible case, but unfortunately not the most usual one. It very often happens that a domical roof must be erected over a building which is square or rectangular in plan, in which case a new and difficult problem must be considered, namely, that of the pendentives. A horizontal section taken through a dome must in every case show a circle or possibly an ellipse. If, then, we consider the horizontal section cut from a domical roof by the plane of the top of the wall, it must usually be a circle and can not exactly coincide with the section cut from the wall of the building by the same plane, unless the building is circular in plan. This is shown in Fig. 256 in which *A B C D* represents the section cut from the wall of the building by a horizontal plane, and the circle *E F G H* represents the section which would be cut from a domical roof covering the building if the framing for the dome were carried down to meet this plane all the way around.

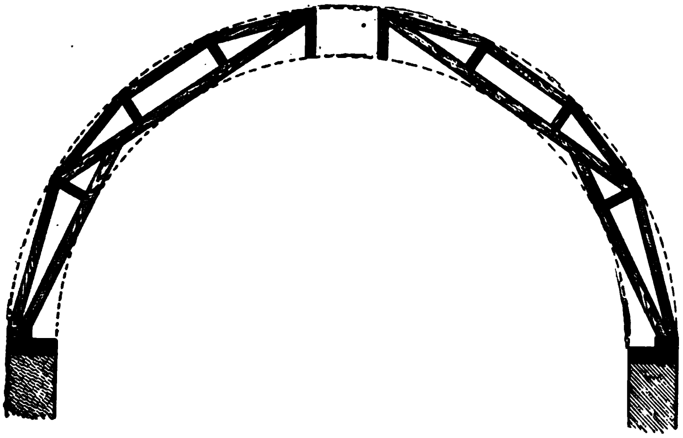

Fig. 255. Section through Domical Roof Showing One of the Ribs

In order to cover every part of the building, the dome must be large enough to include the corners, and if made sufficiently large for this it must overhang the side walls of the building, by an amount *A E B* on each side, if the framing is carried down to the same horizontal plane all the way around. Horizontal sections taken through the dome at intervals throughout its height, however, show smaller and smaller circles as they are taken nearer and

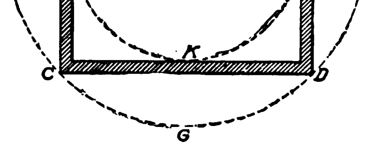

Fig. 256. Diagram Showing Relation of Dome Roof of Square Building

nearer to the top of the dome. Some one of these sections will cut out from the dome a circle which will appear in plan as though it were inscribed in the square formed by the walls of the building. Such a circle is shown at *I J K L* in Fig. 256. A dome built up with this circle as a base would not cover the corners of the building, so that the triangular spaces like *A I L* would be kept open. These triangular spaces, or rather the coverings over them, are called the pendentives. Fig. 257 shows in perspective the outline of four pendentives *E D H*, *H C G*, etc.

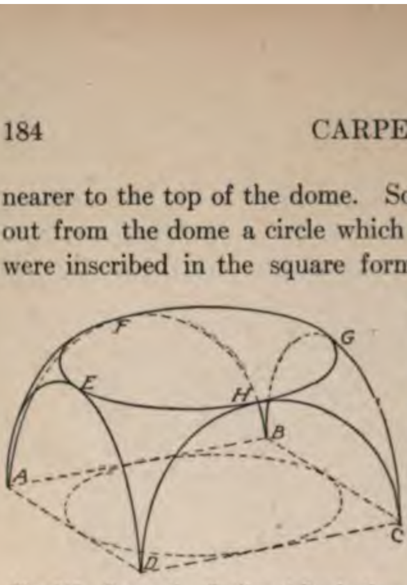

Fig. 257. Perspective Outline of Pendentives

We have seen that a dome built up on the circumscribed circle as a base is too large, while a dome built up on the inscribed circle is too small and will not completely cover the building. To overcome this difficulty it is customary to erect a dome on the smaller or inscribed circle, as a base, and to extend the ribs so as to fill up the corners and form a framework for the pendentives. This is shown in Fig. 258 which is a plan of the framework for a domical roof. The ribs will be of different lengths and will intersect the inside face of the wall at different heights, because as they are extended outward they must also be extended downward. Each one will be curved if the dome is spherical, and straight if the dome is conical. The upper ends of the ribs bear against the curb *A*, leaving a circular opening for a lantern or cupola. The lower ends may be supported on a masonry wall, or may rest on curved wood plates, as shown in Fig. 259. This is an elevation of a conical dome, and shows the straight ribs *A*.

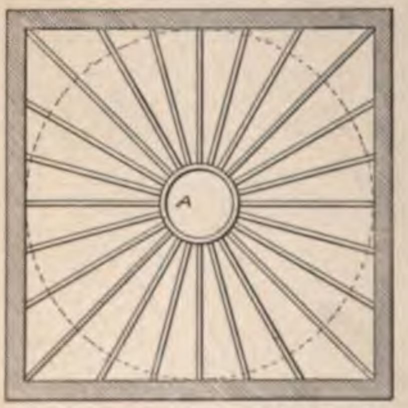

Fig. 258. Dome Framing with Extended Rafters

Fig. 260 shows an elevation of a spherical dome which has curved ribs *A*, as shown. Each of these ribs must be bent or shaped to the segment of a circle, in order that the edges may lie in a spherical surface.

If the design calls for a domical ceiling and the exterior may be of some other form, then only the inside edges of the ribs need be dressed to correspond with a spherical or conical surface, in order that they may receive the lathing or furring, and the outside may be left rough so that a false roof of any desired shape may be built. If the exterior must be of domical form, while on the interior there is a suspended or false ceiling of some kind, then only the outside edges of the ribs must lie in the conical or spherical surface, so as to receive the roof boarding, while the inside edges may be left rough or shaped to any other form. If both the exterior and interior must be domical, then both the inside and outside edges of the ribs must be dressed so as to lie in the domical surface.

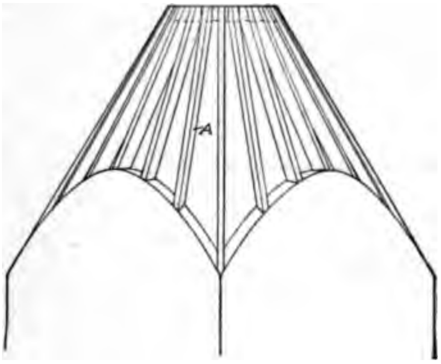

Fig. 259. Diagram Showing Construction for Apex of Conical Dome

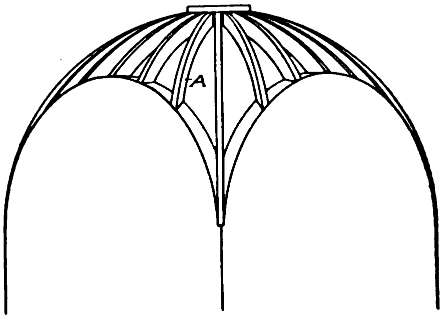

Fig. 260. Diagram Showing Construction for Spherical Dome

Conical domes are very uncommon, but they are sometimes used. A conical dome is much easier to frame than a spherical dome because the ribs are straight. The shape of the curved plate which supports the lower ends of the ribs may be easily determined, since it must conform to the line of intersection between the conical or spherical surface of the dome, and the plane of the face of the wall.

Niches. Niches are of common occurrence in building work, especially in churches, halls, and other important structures. Sometimes they are simply recesses in the wall with straight corners and a square head, but more often they are semicircular in form, with spherical heads, in which case the framing becomes a matter of some difficulty. The framing of the wall for a semicircular niche is the easiest part of the work, since all the pieces may be straight, but for the framing of the head the ribs must be bent or shaped to conform to the surface of a sphere.

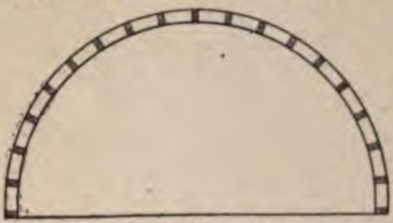
Fig. 261. Plan of Vertical Studding for a Niche

Fig. 261 shows in plan the way in which the vertical studding of the walls must be placed. The inside edges must lie in a cylindrical surface, and will receive the lathing and plastering. There must be a curved sole piece for them to rest upon at the bottom and a cap at the top. The cap is shown at *A B*, in Fig. 262, which is an elevation of the cradling or framing for the niche. This figure shows how the ribs for the head of the niche must be bent. The ribs and vertical studs must be spaced not more than 12 inches apart, center to center.

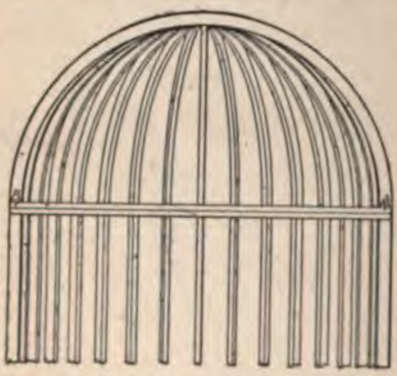
Fig. 262. Elevation of Framing for the Niche

The form of niches described above is the most common one for large niches intended to hold full size casts or other pieces of statuary, but smaller ones for holding busts and vases are quite common. These are often made in the form of a quarter sphere or some smaller segment of a sphere, with a flat base or floor and a spherical head, as is shown in section in Fig. 263. They are framed with curved ribs in the same way as described above, and finished with lathing and plastering.

Vaults and Groins. Although vaulted roofs are an outgrowth of masonry construction, and are almost always built of brick or stone, they are occasionally built of timber, and in any case a timber centering must be built for them. A vault may be described as the surface generated by a curved line, as the line moves through space, and in accordance with this definition there are vaults of all kinds, semicircular or barrel vaults, elliptical vaults, conical vaults, and many others.

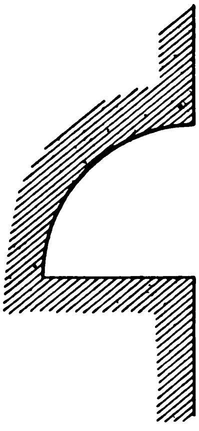
Fig. 263. Section of Small Niche

In Fig. 264 is shown in outline a simple semicircular or barrel vault, known as well by the name *cylindrical vault*. The point *A* where the straight vertical wall ends and the curved surface begins is called the *springing point*. The point *B* is the *crown* of the vault. The distance between the springing points on opposite sides of the vault is the *span*, and the vertical distance between the springing point and the crown *B* is the *rise*.

It may easily be seen how a barrel vault, or a vault of any kind, may be framed with curved ribs spaced from 1 foot to 18 inches apart on centers, and following the outline of a section of the vault. If the framework is intended to be permanent and to form the body of the vault itself, then the inner edges of the ribs must lie in the surface of the vault and must be covered with lathing and plastering. If only a centering is being built, on which it is intended that a masonry vault shall be supported temporarily, then the outer edges of the ribs must conform to the vaulted surface and must be covered with rough boarding to receive the masonry.

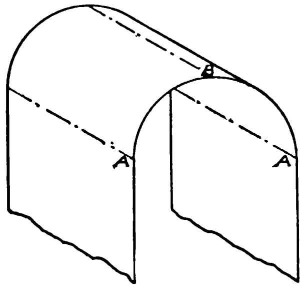

Fig. 264. Diagram of Cylindrical Vault

When two vaults intersect each other, as in the case of a main vault, and the vault over a transept, the ceiling at the place where vaults come together is said to be *groined*. The two vaults may be of the same height or of different heights. If they are of different heights the intersection is known as a *Welsh* groin. Welsh groins are of common occurrence in masonry construction, but in carpentry work the vaults are almost always made equal in height and often they are of equal span as well.

The framework for each vault is composed of ribs spaced comparatively close together, and resting on the side walls at the springing line. When, however, the two vaults intersect each other, the side walls must stop at the points where they meet, and a square or rectangular area is left which has no vertical walls around it The covering for this area must be supported at the four corner points in which the side walls intersect. This is shown in plan in Fig. 265 where *A B C D* are the points of intersection of the walls of the vaults. The method of covering the area common to both vaults is also shown in the figure. Diagonal ribs *A D* and *C B* are put in place so as to span the distance from corner to corner and these form the basis for the rest of the framing. They must be bent to such a shape that they will coincide exactly with the line of intersection of the two vaulted surfaces. The ribs which form the framing for the groined ceiling over the area are supported on the diagonal ribs as shown in the figure. They are arranged symmetrically with respect to the center, and are bent or shaped to the form of segments of circles or ellipses.

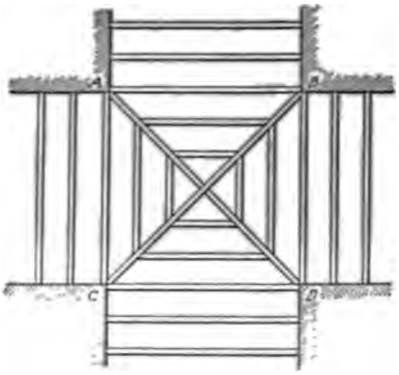

Fig. 265. One Method of Cradling for Groined Ceiling

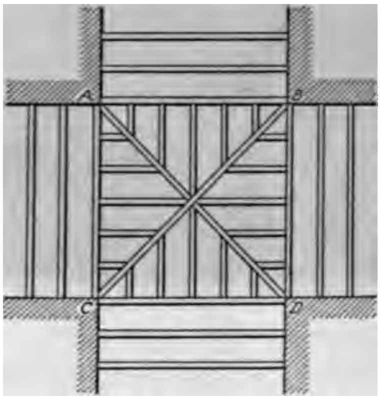

Fig. 266. Another Method of Cradling for Groined Ceiling

Fig. 265 shows one method of forming the cradling for a groined ceiling, but there is another which is also in common use. This is shown in Fig. 266. There are four curved ribs *A B, B D, C D,* and

C A, which span the distances from corner to corner around the space to be covered. The diagonal ribs *A D* and *C B* are also employed as in the first method. Straight horizontal purlins are supported on these ribs, running parallel to the direction of the vaults, as shown in the figure. They are spaced about 16 inches apart and form the framework for the ceiling.

The only difficult problem in connection with groined ceilings is to find the shape of the diagonal rib. This rib, as has been explained above, must coincide with the line of intersection of the vaults. The problem, then, is to find the true shape of the diagonal rib.

Let us consider the two vaults shown in plan in Fig. 267. They are not of the same span, but they will be of the same height if we wish to have a common groin and not a Welsh groin; so if one is semicircular the other must be elliptical. Elevations of ribs in each vault are shown at *A* and *B* and the diagonal ribs are shown in plan at *A C* and *B D*. It is easy to find the plan of these ribs because they must pass from corner to corner diagonally. To find the elevation we must use the same principle that was employed in finding the position of the valley rafter and the shape of the curved hip rafter for an ogee roof, namely, any line drawn in the roof or ceiling surface parallel to the plate or side walls must be horizontal, and all points in it must be at the same elevation.

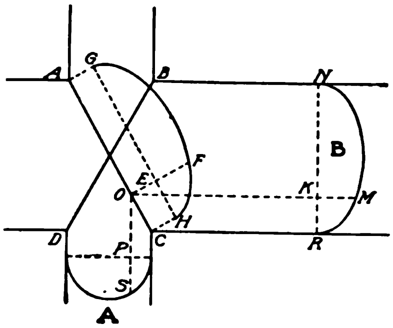

Fig. 267. Diagram Showing Method of Finding Diagonal Rib for Two Intersecting Vaults

We start with the assumption that one of the vaults is semicircular, as shown in elevation at *A*, Fig. 267. Taking any line in the vaulted surface, shown in plan, as the line *S P O*, we produce it until it intersects the plan of the diagonal rib *A C* at the point *O*. This point must be the plan of one point in the line of intersection of the vaulted surfaces.

The elevation of the point *O* above the springing line of the vaults is shown by the distance *P S*, since the line *S P O* is exactly horizontal throughout. This distance is laid off at *E F* with the [illegible] the horizontal plane which contains the [illegible]nes [illegible]aults. The point H is the point from which [illegible] diagonal rib starts. The point F, as we have seen, is another point in the curve, and we can by a similar process locate as many points as we need. This will enable us to draw the complete curve GFH of the line in which the vaults intersect, and to which the diagonal rib must conform.

By continuing the line from the point O at right angles to its former direction and parallel to the wall line, we may obtain the point K, which is a plan of one point in the surface of the elliptical vault. The elevation of this point also above the springing lines must be the same as for the point S a[illegible] be laid off, as shown at KM. By finding other points in a si[illegible]ay the curve NMR of the elliptical vault may be readily det[illegible]ed.

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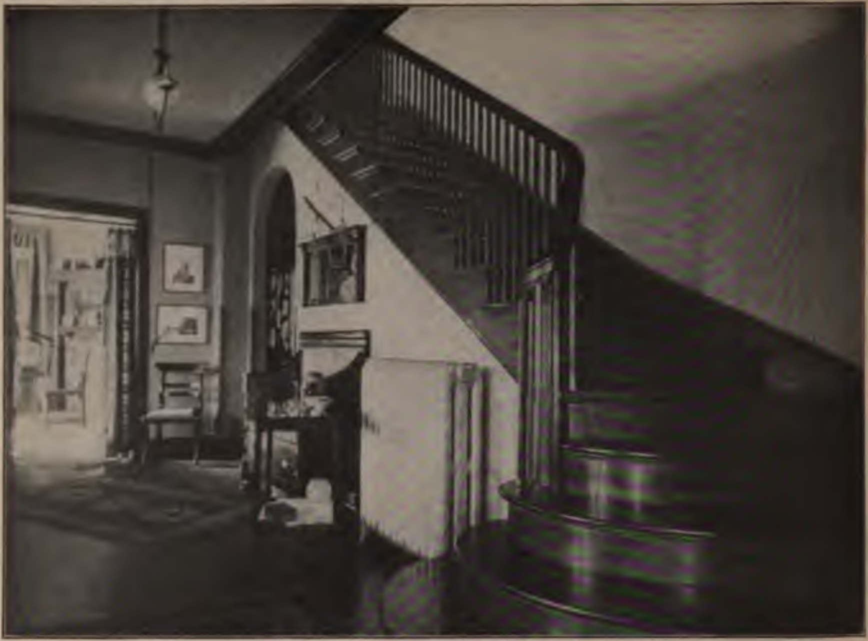
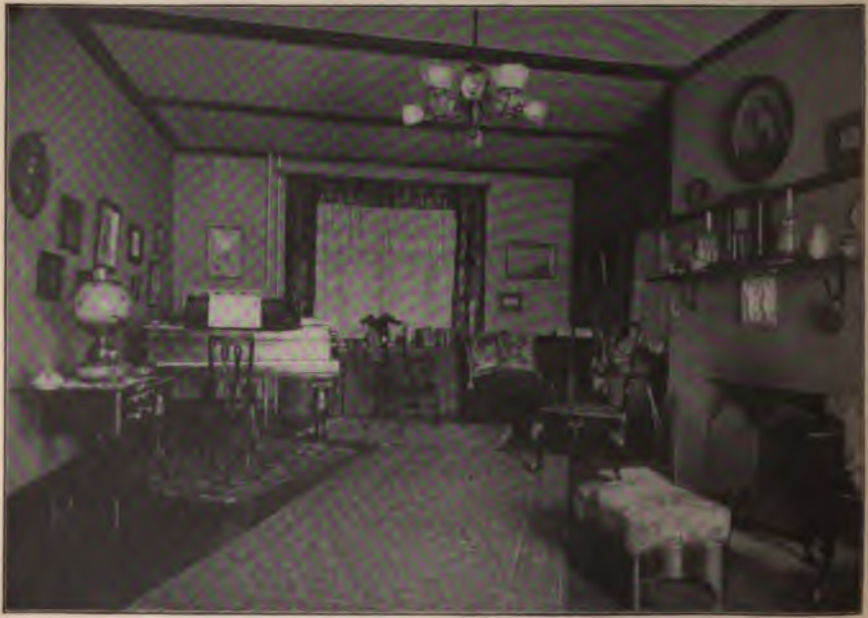


STAIR HALL OF HOUSE IN URBANA, ILL.



LIVING ROOM OF HOUSE IN URBANA, ILL.
White & Temple, Architects, University of Illinoi
For Exterior and Plans, See Page 266.

CARPENTRY

PART IV

EXTERIOR AND INTERIOR FINISH

In the preceding pages we have considered the most important of the methods in use for the construction of the rough framework of buildings. We will now take up the general subject of finish, both outside and inside. There are two things which the outside finish of a building is intended to do: first, to protect the vital part of the structure—the framework; and second, to decorate this framework and to make it as pleasing in appearance as may be possible. Both of these purposes must be borne in mind when designing or erecting any outside finish, as both are equally important and neither should be neglected.

Material. The material used for the finish varies under different conditions and in different parts of the country. Of course, it must first of all be durable when exposed to the weather, and it must be a wood which can be easily worked. The best kinds of wood for the purpose are white pine and cypress, and one of these woods is generally used. Spruce and Georgia pine are sometimes used on cheap work, but they are much inferior to white pine. Poplar is very good but scarce. Pine should be employed wherever it is obtainable.

OUTSIDE WALL FINISH

Sheathing. The first operation in connection with the application of the finish is that of covering the framework with sheathing, which should be about 1 inch in thickness, and for the best work, dressed on one side. The sheathing should be placed diagonally across the studding when the frame is of the "balloon" variety, but in case of a braced frame the boards need not be so placed. With the braced frame, the boarding may be started at any time, but with the balloon frame it is necessary to wait until all of the studding

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has been placed in the outside walls. The sheathing should be laid close, but need not be matched, and the boards should be fairly wide, say 8 to 10 inches, or even more. The most common material for this work is yellow pine free from loose knots. Spruce or hemlock may be used with good results.

The roof sheathing is nailed on at right angles to the rafters but the boards are narrower. The width is usually 4 inches but 6 inches works well also. They are laid with spaces between them for the passage of air. These spaces are from 2 to 3 inches wide and are left for the ventilation of the shingling or other roof covering, and for the cheapening of the rough boarding.

Roof boarding is not laid diagonally, but if this were done a very much stronger building would be obtained than where the boarding is laid horizontally, because each board acts somewhat as a truss to bind the whole framework more securely together. Some curved work, such as round towers and bay windows, is boarded diagonally, when it is impossible to place the boards in any other way. Each piece should be well nailed to each stud or rafter with large nails, ten-penny or eight-penny, and no serious defects such as large knots should be allowed in the sheathing.

Building Paper. Building or sheathing paper is now placed over the sheathing to keep out the weather and to cover more completely the joints in the boarding. This paper must be tough and strong as well as waterproof, and must be easy to handle and put in place. It must not be easily broken as any hole in it is an opening through which the weather will surely find its way. There are a number of different kinds of building paper on the market, prepared with various chemicals to render them as nearly waterproof as possible. Tar is sometimes used for this purpose. The paper should always be laid with a good lap.

Water Table. Starting at the bottom of a wood structure, at the point where the masonry foundation wall stops and the timber framework begins, the first part of the outside finish which meets the eye is the water table, so called because its purpose is to protect the foundation wall from the injury which would result if water were allowed to run down the side of the building directly onto the masonry. The water table, therefore, must be so constructed as to direct the water away from the top of the foundation wall. This may be accomplished in several ways, some of which will be described and illustrated.

Fig. 268 shows the simplest form which can be used for a building which is to be covered with clapboards (this covering will be discussed later). *A* is the foundation wall, which may be stone, brick, or concrete. *B* is the sill, which may be in one or two pieces and which has already been described at length. *C* is the boarding or sheathing, which in this case is flush with the outside of the foundation wall, the sill being set back about 1 inch from this face. The board *D* is nailed so as to cover the joint between the top of the foundation wall and the sheathing, and on the top of it is fastened the water table *E*, which is inclined downward and outward so as to shed the water. The piece *F* is inserted to set out the first and lowest piece of siding *G*.

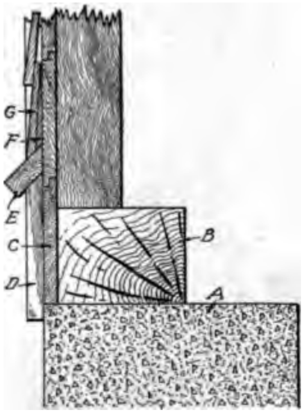


Fig. 268. Simple Form of Water Table

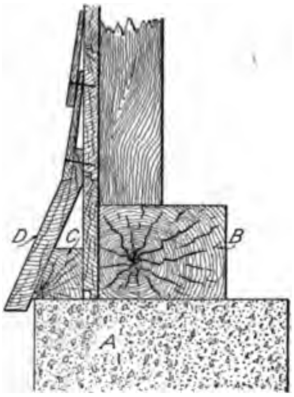


Fig. 269. Type of Water Table with Rabbeted Table Board

Fig. 269 shows another way of constructing a water table for a building with clapboards. In this case the sill *B* is set back about 4 inches from the face of the wall *A*, and a block is nailed to the bottom of the boarding, as at *C*, so as to set the piece *D* out clear of the face of the wall. This piece is rabbeted at the top as shown, so as to take in the bottom of the last clapboard.

Another method is shown in Fig. 270. In this case the board *D* is again made use of to cover the joint between the sheathing and the foundation wall, and it is nailed directly to the boarding as before, but the piece *E* is much larger and is blocked out by means of the addition of the piece *G*, so as to throw the water well away from the masonry. In many respects this detail is the best of the three, as the joint is well covered and at the same time there is provided a very good wash for the rain water. There are many other ways of building this part of the finish, but only one more will be shown for use when the walls are to be covered with shingles. Fig. 271 shows how this should be done. Two or even three blocks, as at *F*, are nailed to the boarding and the shingles *G* are bent over them so as to shed the water free of the masonry without further help. They may be finished at the bottom with a molded piece *D* to hide the joint.

The water table is sometimes omitted entirely and the clapboarding is started directly from the foundation wall, but this is not considered good practice and will surely be found to be unsatisfactory.

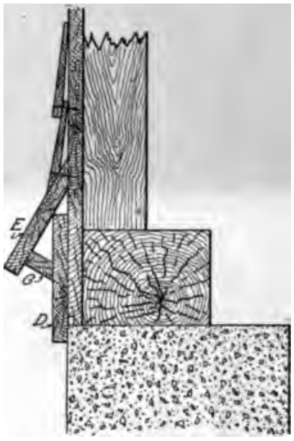


Fig. 270. Water Table of Simple Construction

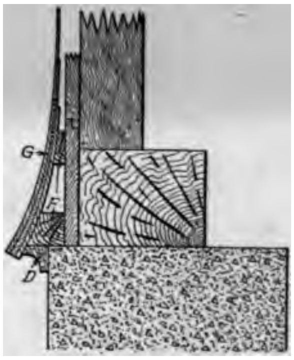


Fig. 271. Water Table Used with Shingled Walls

Clapboards for Wall Covering. The clapboards used for covering walls are usually of white pine or spruce, though they are sometimes made from a cheaper timber such as hemlock or fir. They are about 5 or 6 inches wide and about 4 feet long and are thicker on one side or edge than on the other. The thicker edge measures about ½ inch while the thin edge is only about ⅛ inch thick. Each clapboard, therefore, is as shown in Fig. 272, where *A* is an elevation and *B* is a section of the board. The tapering section is obtained by sawing the boards from a log, cutting each time from the circumference inward. The boards are thus all quarter sawed and shrink evenly, if at all, when they are exposed. When laid up on the side of a building, the clapboards should lap over each other at least 1½ inches, as shown in Fig. 273. Here, *A* is the clapboarding, *B* is the sheathing, and *C* is the studding. As will be seen, the clapboards lap over each other, leaving a certain amount of each board exposed to the weather. This term "to the weather" is made use of in many specifications to indicate the amount of board which is to be exposed. Thus, "4 inches to the weather" means that 4 inches will be exposed. Building paper should be placed between the clapboarding and the sheathing, as shown at *D*, to keep out the weather.

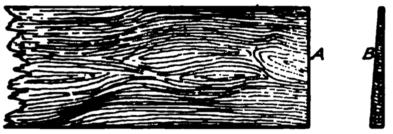


Fig. 272. Side and End Views of a Clapboard

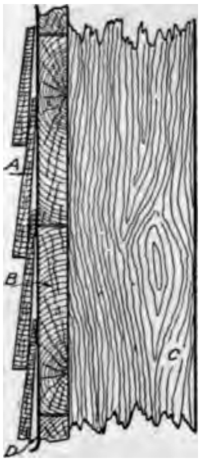


Fig. 273. Section Showing Method of Laying Clapboards

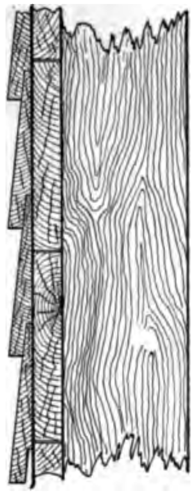


Fig. 274. Section Showing Method of Laying Siding

Siding. The only difference between common siding and clapboards is in the length of the pieces, the siding coming in lengths of from 6 to 16 feet, while the clapboards are in short lengths as explained above. Common siding is put on in the same way as clapboards, but there is manufactured a rabbeted siding which is laid up as shown in Fig. 274. Here the rabbet takes the place of the lap, and is made about $\frac{5}{8}$ inch deep. This siding is also furnished molded to a number of other patterns besides the simple beveled pattern, and is of various widths up to about 12 inches. Sometimes it is nailed directly to the studding, no building paper or outside boarding being used, but this construction, although it is cheap, is not suitable for any but temporary buildings.

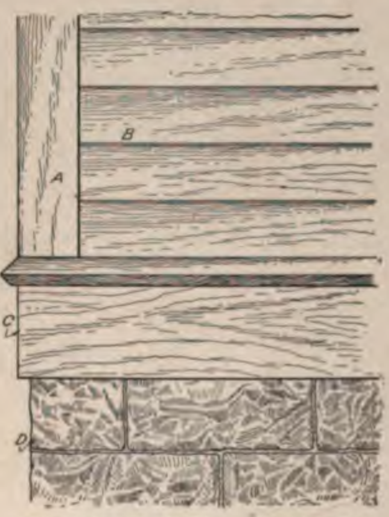


Fig. 275. Simple Corner Board in Place

Corner Boards. It is customary, whenever the walls of a building are covered with clapboards, to make a special finish at the corners. This finish usually takes the form of two boards, one about 5 inches wide, the other $3\frac{7}{8}$ inches wide by about $1\frac{1}{8}$ inches thick, placed vertically at each side of the corner so as to project $1\frac{1}{8}$ inches—the thickness of the board—beyond the face of the sheathing. Thus they form something for the clapboards to be fitted against. The corner boards may be mitered at the corner, but this is not desirable, as it is hard to make such a joint so that it will not open up under the influence of the weather. The corner boards are, therefore, usually finished at the corner with a simple butt joint, the two pieces being securely nailed together. In some styles of work it may be

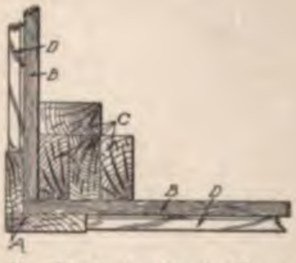


Fig. 276. Section Showing Corner Board Construction

Fig. 277. Shingled Wall Requires no Corner Board

well to give the corner boards a special character, and this can be done by crowning them at the top with a capital, so that they will form a sort of pilaster at each corner of the house. A base may also be added if desired, though it is hard to make a base finish well on top of the water table. Fig. 275 shows a view of a simple corner board in place on the outside corner of a house. *A* is the corner board, *B* is the clapboarding, *C* is the water table, and *D* is the foundation wall. Fig. 276 shows a section taken horizontally through the corner of a building with corner boards and clapboards, showing how the corner boards are applied to the outside boarding. In this figure, *A* is one of the corner boards, *B* is the outside sheathing, *C* is the studding at the corner built up of 2×4-inch pieces, and *D* are the clapboards. The width of the boards may, of course, be varied to suit the taste of the designer.

When the walls of the building are to be covered with shingles it is not necessary to have corner boards, as the shingles can be brought together at the corner and made to finish nicely against each other. The usual method is to allow the shingles on the adjacent sides to lap over each other alternately as shown at *A* in Fig. 277.

Shingles. Instead of clapboards, shingles may be used for covering the walls of a building, though this method is more expensive than the other. The advantages are in the appearance of the work, the variety of effects which may be obtained, and also in the fact that the shingles may be more easily dipped in some stain and a greater variety of colors thus obtained. Wall shingles should be laid with not more than 6 inches to the weather, and an exposure of 5 inches is better, but even if 6 inches are exposed, there will be a greater thickness of wood covering any particular spot of the wall with the shingling than there is with the clapboarding, and thus a greater protection from the weather is obtained. The arrangement of shingling on a wall is shown in Fig. 278. It will be seen that the shingles are in all cases two layers and in some cases even three

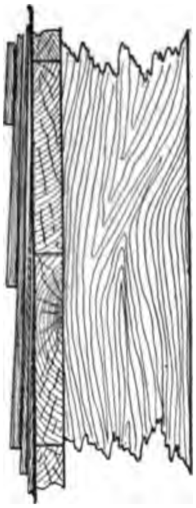


Fig. 278. Section of Shingled Wall

layers thick. The width of ordinary shingles varies from about 3 inches to about 12 inches, and for rough work these widths may be used at random, but shingles which are called "dimension shingles," and are cut to a uniform width of 6 inches, may be had and these should be used for any careful work. Also shingles may be obtained which have their lower ends cut to a great variety of special and stock patterns, which may be worked into the wall so as to yield any desired effect. A shingled wall is shown in elevation in Fig. 277. Building paper should be used under shingles in the same way as under clapboards.

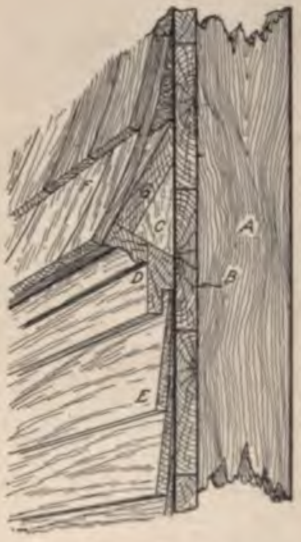


Fig. 279. Details of Belt Course

Belt Courses. It is often desirable, for the sake of effect or for the purpose of protecting the lower part of the walls of a building, to arrange a horizontal projecting band or "course," as it is called, which will slightly overhang the lower part of the wall. This is called a "belt course" and usually occurs at or near a floor level or across the gable end of a building at the level of the eaves. A belt course is formed by placing blocks or brackets at intervals against the face of the outside boarding, these blocks being cut to the required shape to support thin pieces of molding. This arrangement is shown in section in Fig. 279. Here, *A* is the studding, *B* is the boarding, *C* is the block or bracket, *D* is the finish under the block, *E* is the wall shingling, *F* shows where the shingles come down over the belt course and the furring *G* supports the finish and provides nailing surface for the first course of shingles. A similar belt course may be placed on a building with any other kind of wall covering, the principle being the same in every case, and the purpose being always to form a projecting ridge from which the water will drip without injuring the wall surface beneath. Sometimes the wall covering is not brought out over the top of the belt course, but is stopped immediately above it, and in this case care must be taken to see that the top of the course is well flashed with galvanized iron or copper so that the water can not get through the wall around it. It is best to cover the entire top of the belt course with the flashing and to run it up onto the vertical wall 4 or 5 inches with counter flashing over it. The method of flashing will be explained later.

OUTSIDE ROOF FINISH

Finish at the Eaves. The point, or rather the line, in which the sloping roof meets the vertical wall is called the "eaves" and this point must always be finished in some way. This finish, however, may be varied to almost any extent, and it may be very simple, so as to barely fulfill the necessary requirements, or it may be very elaborate and ornamental as well as practically useful.

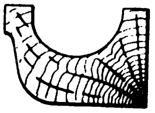


Fig. 280. Simple Gutter

Gutters. Practical considerations require that at the eaves some kind of a gutter must be provided, to catch the water which falls on the roof and streams off from it. This gutter, of whatever kind, must be supported far enough away from the straight vertical wall of the building so that the water dripping from it in the case of a possible overflow will fall free of the walls and not injure them. Usually, the gutter ought not to be nearer to the wall than one foot.

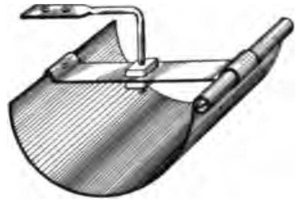


Fig. 281. Metal Gutter

There are a number of different kinds of gutters in use, and perhaps it will be as well to describe some of them at this time, as they form a part of the eave finish. The simplest kind is made of wood, and is generally kept in stock in several different sizes by lumber dealers. It is of the general shape shown in section in Fig. 280, and the most common sizes are 4×6, 5×7, and 5×8 inches. They are usually made of white pine, but may better be made of cypress or redwood. Spruce is hardly durable enough for use as a material for gutters. Besides the wood gutter just described, there are in use a number of different forms of metal gutters, some of which are carried in stock by dealers in roof supplies and others which must be made to order by the roofer for each particular job. The metal gutters are made of galvanized iron, copper, or of a tin lining in a wood form. Any wood gutter may be improved by lining it with tin or zinc, and there should always be a piece of one of these metals used to cover the joint between the two pieces of a wood gutter where they meet. Wood gutters can be had only in lengths of about 16 feet at the most, so usually there must be some joints to be covered with metal. The simplest metal gutter takes the form of a trough, as shown in Fig. 281, and is fastened in place by hangers placed at frequent intervals or by brackets which answer the same purpose. Either the hangers or the brackets may be spiked to the ends of the rafters, and thus a cheap and simple gutter may be obtained.

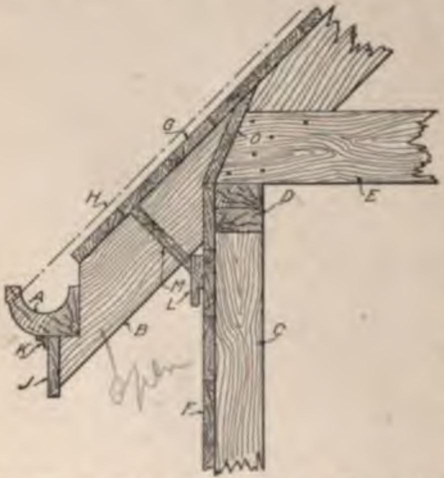


Fig. 282. Section Showing Open Cornice Construction

Open Cornice. The most simple way of supporting the gutter is to let the main rafters of the roof framing extend out over the wall as far as necessary and cut a rabbet in the end of each of them into which the gutter will fit. In this case the wood gutter should be used. It is fastened into the notches left in the ends of the rafters, as shown in Fig. 282. In this figure, *A* is the gutter, *B* is the rafter, *C* is the studding of the building, *D* is the plate with the rafters cut over it and the ceiling joists *E* resting on top of it, *F* is the outside boarding, which may be covered with clapboards or shingles, and *G* is the roof boarding, which may be covered with shingles or slates. In one respect the construction shown in this figure is faulty, because the gutter being placed in the position shown, snow sliding off the roof would catch the outer edge of it and perhaps tear it off. The gutter should, wherever possible, be placed low enough so that the line of the finished roof, *H* in the figure, will clear the edge of it. In order to improve the appearance of the eaves it is well to place a board *J* along the edge of the rafters so as to hide them and present a plain surface to the eye and to finish the joint between this board and the under side of the gutter with a small bed molding *K*. Underneath the rafters where they cross the plate and come through the outside boarding is placed a board *L* which forms a stop for the siding or shingles, and another board should be inserted between this and the under side of the roof boarding, as shown at *M*. It is also a good plan to cover the ends of the ceiling joists with a strip of boarding to keep the wind out of the roof space. This is shown at *O*. The finish shown in Fig. 282 is of the simplest and barest kind and can be used only for buildings of an unimportant character such as stables and outhouses or for cheap country houses.

Boxed Cornice. A better finished form of cornice is shown in Fig. 283. Here an extra piece *P* is placed just above the gutter so as to cover the spaces between the rafters, and the entire under side of the rafters outside of the wall of the building is covered with boarding as at *Q*, so that the rafters will not be seen at all. The piece *L* must still be used, however, to stop the wall covering. This figure also shows the roof shingling at *R*. This should be laid about 4 to 4½ inches to the weather. It is laid closer than the wall shingling because it is nearer flat and the water will stand on it longer than it will stay on the wall. The water thus has a greater chance to leak through and the shingling must be laid closer and thicker on the roof. It is wise to insert blocks on top of the plate as shown at *S*, and to continue the side sheathing up to the roof sheathing so as to make everything tight. All of the boarding used for the boxing in of the rafters at *Q*, together with the pieces *L* and *J*, may be of ⅞-inch stuff. The piece *P* should usually be of 1⅛-inch stuff so as to allow of rabbeting it to receive the gutter. The piece *K* may be molded as desired by the designer of the building. *J* is called the *fascia* and *Q* is called the *planceer*.

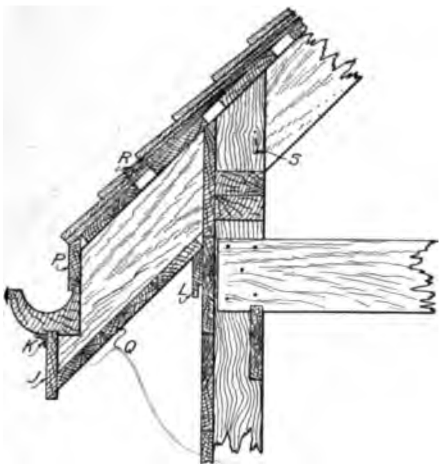


Fig. 283. Section Showing Boxed Cornice Construction

The principal objection to the boxed cornice is that, if snow melts in the gutter and freezes afterward so as to fill up the gutter during the winter, it is very likely to work its way up under the shingles when it finally melts in the spring, and in this way find its way into the attic. In the case of the open cornice there is little chance of this happening, as the water can get away at the back of the gutter between the rafters.

Sometimes it is desired to place the planceer in such a position that it will be horizontal instead of following up along the under side of the rafters. This is accomplished by fastening a piece of furring to the end of the rafter and to the wall in such a way that the bottom of it will be horizontal, and spacing these pieces 12 or 16 inches apart all around the eaves of the building. To this furring can be nailed the planceer which will box in the cornice and be in a horizontal position. The gutter can still be fastened to the end of the rafters as before. This construction is shown in Fig. 284. The pieces of furring referred to are shown at *A*.

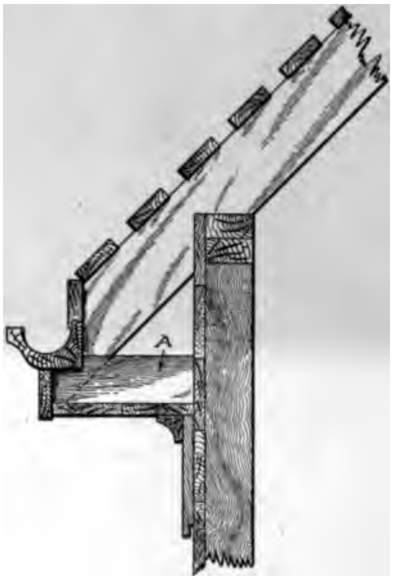


Fig. 284. Boxed Cornice with Horizontal Planceer

False Rafter Construction. It is often desirable, for the sake of architectural effect, to break the surface of the roof just above the eave line, and in order to do this it is necessary to make use of small pieces of rafters, called false rafters, or sometimes "jack" rafters, which are nailed to the ends of the regular rafters. In this case the regular rafters stop at the point where they rest on the plate, and the false rafters project out over the wall line as far as may be desired. These false rafters are cut into various shapes and are usually left exposed on the under side, being in this case made of a better and harder class of wood than that used for the regular rafters. The gutter may be placed on the ends of these false rafters if desired, but it is more usual to make use of a construction such as is shown in Fig. 285. Here it will be seen that the gutter is merely formed up on top of the roof shingling by a piece *A* which is held in place by the bracket *B*. The brackets occur at intervals of about 2 feet, while the piece *A* is continuous. The shingles which cover the roof are stopped on the strip *C* and the inside of the gutter thus built up is covered with galvanized iron, or copper, to make it water-tight. The ends of the rafters may be finished with a fascia as shown at *D*, and the space between the false rafters along the wall may be finished as shown at *E*. In place of the wood piece *A* which forms the outside member of the gutter, a piece of metal may be used to accomplish the same purpose, and this is often done.

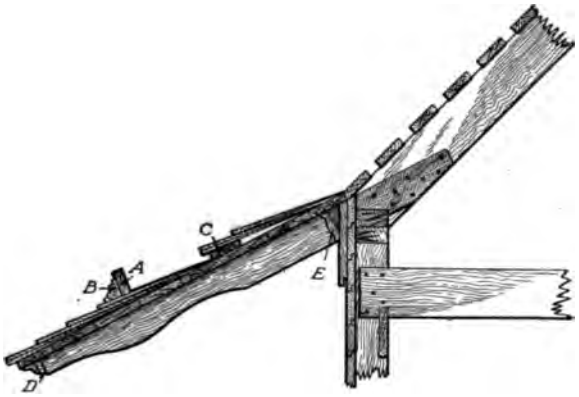


Fig. 285. False Rafter Construction with Shallow Gutter

Concealed Gutters. Another common form of eave provides a concealed gutter. In this construction the ceiling joists are extended beyond the outside walls and the rafters are cut to set over the plate. The cornice and gutter are illustrated in Fig. 286. The studding is shown at *S*, and on the plate *P* the joists *C* extend over from 8 to 14 inches, depending on the effect desired. Around the joist the planceer *Q*, the fascia *J*, the bed *N*, and crown molding *M* are fixed. A notch *O* is cut in the joist and a $\frac{7}{8}$-inch piece is nailed in this notch and on the outer end. Tin or copper is used to conduct the water over the gutter. The tin should be nailed to the crown molding and should be run 8 or 10 inches above the shingle line.

Finish for Brick Walls. Any of the forms of eave finish described above may be used equally well in cases where the wall is of brick instead of wood. In this case a wood plate is placed on top of the brick wall and the rafters are brought down over it, and are either extended out over the wall or are fitted with false rafters. The joint between the brick wall and the wood rafters is finished with a wood frieze.

Cornices may be much more elaborate than any of those illustrated above, indeed those shown here are suitable only for the plainest and cheapest kind of work, but the principles of construction are the same in all cases, the difference being in the amount of ornament applied to the building. The ornament takes the form of molded pieces of timber which are supported by rougher furring pieces placed behind them. Economy demands that the finished pieces be so arranged as to be cut out of boarding of medium thickness, and as much space as possible should be occupied by the rough, concealed furring. As a rule, all of the eave finish can be taken out of ⅞-inch stuff. Care must be taken always to give the gutters the proper slope to the outlets called "downspouts" and they should be made large enough so as not to overflow. A gutter should slope ⅜ inch to the foot.

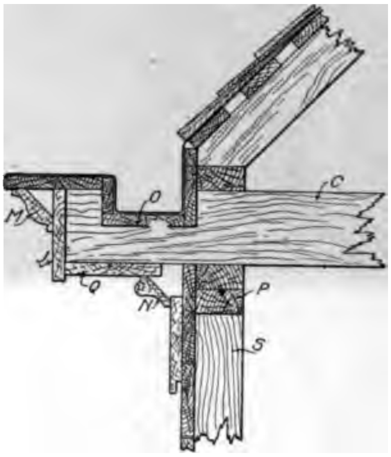


Fig. 286. Cornice Construction for Concealed Gutter

Ridge Finish. At the ridge of a roof where the two slopes meet there must be some special provision made for the proper finish of the roof covering, something for the shingling or slating to finish on as well as some adequate means of covering and making watertight the joint which occurs at this place. There is usually a ridge board, or ridgepole, which receives the rafters, and this piece may be cut off just at the ridge so that the rough roof boarding goes over it, or it may be made wider and may project up above the roof boarding, so that this boarding stops against it instead of going over it. The two different methods call for different kinds of ridge finish. The first is the *most* simple, and may be taken care of as shown in Fig. 287. Here, *A* is the ridge board, *BB* are the rafters, *E* is the roof boarding, *C* is the shingling, and *D* is the finish at the ridge, consisting of two pieces of board about 6 or 8 inches wide and $\frac{7}{8}$ inch thick, which are nailed on top of the shingling to form a finish. In case the ridge board is carried up above the roof boarding, it is customary to make the ridge finish of galvanized iron or of copper or other metal. This may be done very simply, as shown in Fig. 288. Here the ridge board is extended above the roof boarding and around it is shaped a strip of galvanized iron or copper or zinc, which is continued down over the shingles of the roof so as to form a flashing. This makes a good ridge finish and one which is water-tight if it is properly put on. The galvanized iron should be flashed down over the shingles for a distance of at least 6 inches. It is not necessary that the ridge board should be extended above the roof boarding. The same result may be accomplished by nailing a separate piece of 2×4-inch or 2×5-inch scantling to the top of the shingles, running lengthwise of the roof, to form a ridge over which the metal may be shaped. This method may perhaps make a tighter job than the other.

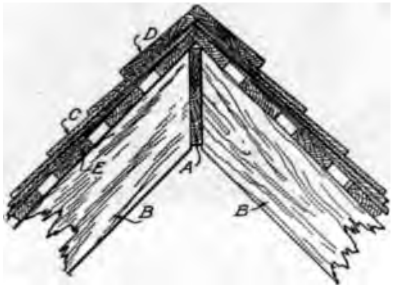


Fig. 287. Simple Ridge Finish

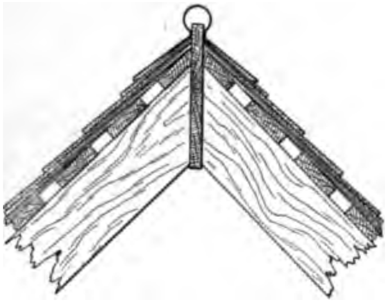


Fig. 288. Galvanized Iron Ridge Finish

Skylight Openings. It is sometimes necessary to make an opening in a roof surface for the admission of light to the rooms under the roof. This is usually done by the formation of what is known as a dormer window, the method of framing for which has been already described, but often it is desired to admit light when the attic space is not of sufficient importance to justify the introduction of a dormer window in the roof. In this case recourse is had to a skylight. A skylight may be obtained by the use of glass in the roof surface in place of other roof covering such as roof boarding and shingles, but it is almost always necessary to provide some sort of frame for this glass, and the glass surface is usually raised about 6 or 8 inches above the shingled roof surface so as to keep the glass as free as possible from snow and to separate it from the general roof surface. The first thing to be done is to frame an opening, in the rough, between the rafters, by introducing trimmer pieces just above and below the place where the opening is to be. This completes the rough framing for the skylight. The finished opening may be formed in a number of ways, one of which is shown in Fig. 289. Here, *AA* are the pieces referred to above, which frame between the rafters *BB* and form the rough opening. *D* is the roof boarding which is brought up to the edge of the opening as framed, and sawed off flush with it as shown. *CC* are pieces of rough stuff which are nailed on top of the boarding to raise the skylight above the roof surface. They may be of any size desired, but in this case they are 4×6 inches. *EE* is sheathing about ⅞ inch thick which forms a finish for the inside of the skylight opening. It is con-

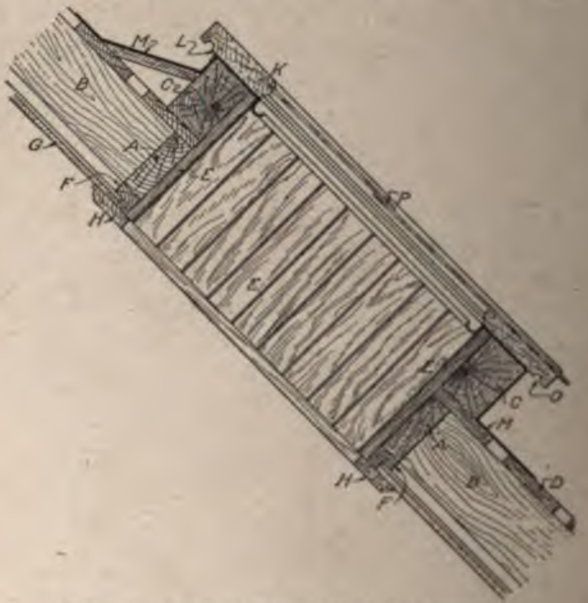
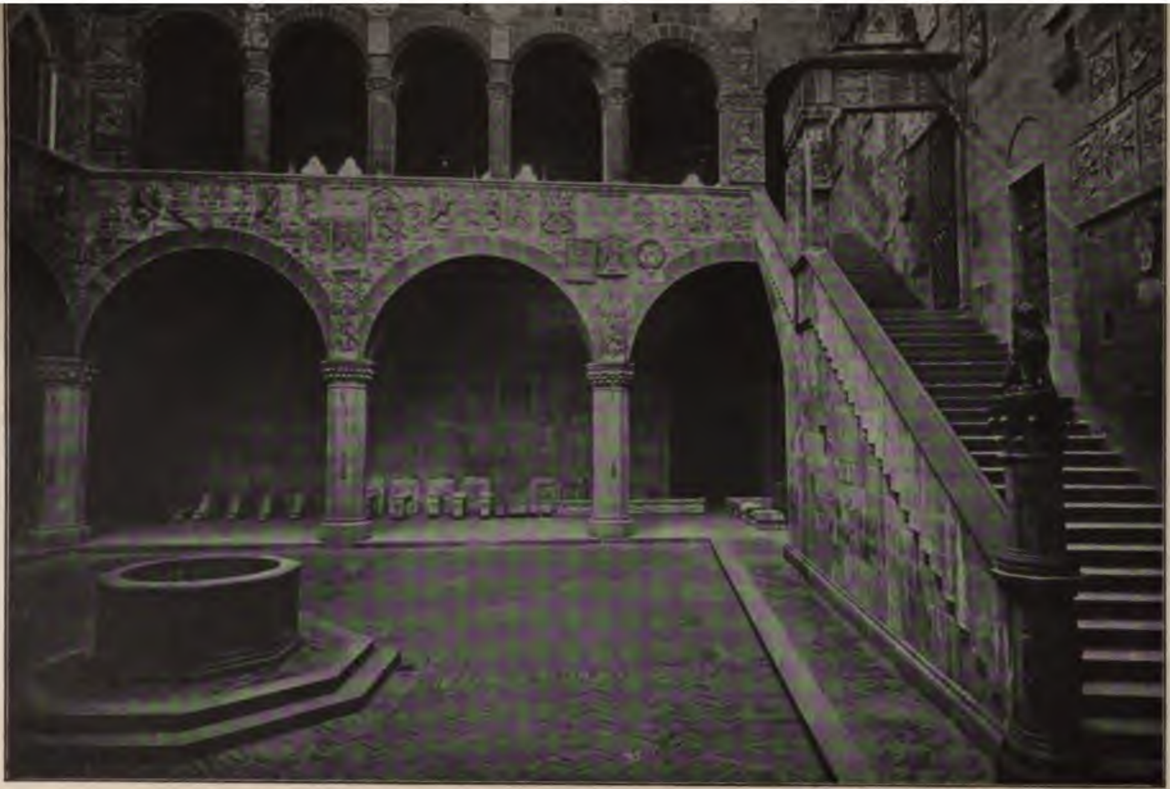


Fig. 289. Section Showing Skylight Construction



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tinued to the top of the pieces *CC* and down to the plaster line inside under the roof so as to cover up all the joints. This sheathing may be V-jointed or beaded if desired. *FF* is furring on the under sides of the rafters, and *G* is the plastering under the roof. *HH* are finishing pieces covering the joint between the sheathing and the plaster. These pieces are called casing. *MM* is flashing of some kind of metal, which should be carried well under the shingles

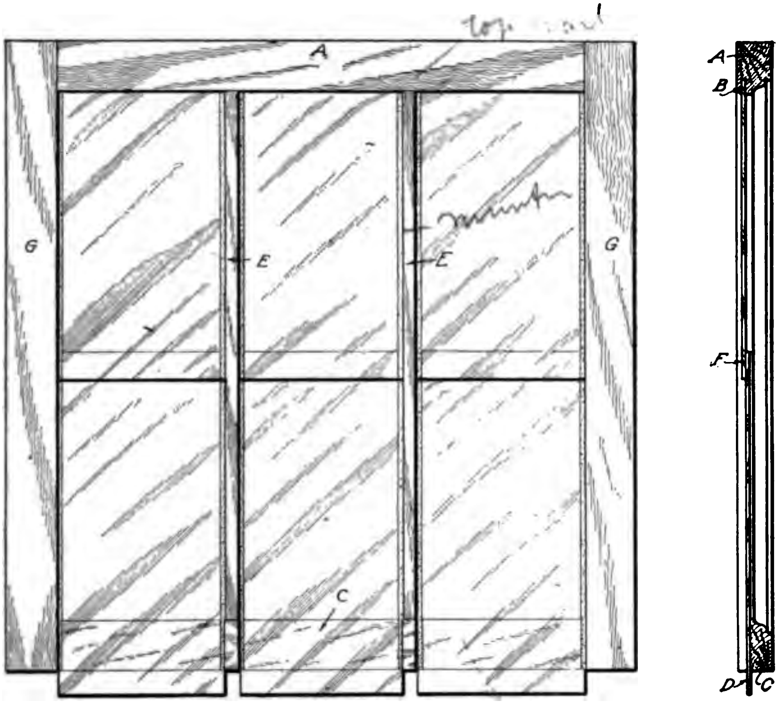

Fig. 290. Plan and Section of Skylight Window

or other roof covering all around the skylight, and is carried inside to form a little gutter around the inside of the skylight just under the glass as shown, in order to catch drippings from the glass. *K* is the sash which holds the glass. It should be hinged to open at the top at the point marked *L* and should project an inch or two beyond the frame all around and have a drip cut in it as shown at *O*. Fig. 290 shows an elevation and a section through a sash suitable for use in a skylight. *AA* is the top rail which is ploughed to receive the glass as shown at *B*. The bottom rail *CC* is made thinner than the top rail so that the glass can pass over it and project beyond it as shown at *D*. *EE* are divisions called "muntins" running lengthwise of the skylight, their distance apart and the number of them required depending upon the width of the sheets of glass used. The muntins support the sheets of glass at the sides, as shown in Fig. 291, which is a section through a single muntin. In this figure, *A* is the wood muntin itself, *BB* is the glass on each side, and *CC* is the putty which is used to hold the glass in place and to make the joint tight. In a skylight sash there should be muntins running lengthwise of the sash only, and the glass should be supported only at the side. If the sash is so long that a single sheet of glass will not cover it, two or more pieces should be used and should be lapped on each other at the ends as shown at *P* in Fig. 289 and at *F* in Fig. 290. This lap should be from 1½ to 2 inches. The side pieces of the skylight sash, *GG* in Fig. 290, should be cut similar to the muntins to receive the glass.

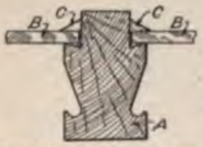

Fig. 291. Cross Section of Muntins

There are a number of other methods of constructing skylights besides the one shown in Fig. 289. The construction of the sash, however, is always about the same as there shown and as described, the difference being in the form of the frame. The pieces marked *C* in the figure are sometimes omitted entirely, and the sheathing *E*, which is only about ⅞ inch in thickness, is replaced by planking 1½ to 2½ inches thick. Such planking is stiff enough to be allowed to project 6 or 8 inches above the roof boarding and it thus takes the place of the pieces *C*. The sash then rests on the ends of this planking, as shown in Fig. 292. In this figure, *AA* is the rough framing similar to that in Fig. 289, *BB* are the rafters, *CC* is the planking mentioned above, which, it will be noticed, does not extend down to the plaster line on the inside, but is stopped about 3 inches above it and is pieced out with a strip of ⅞-inch stuff, *DD* the joint between the two pieces being covered and eased off by a molding *EE*. The architrave *HH* is made use of in this instance also. Other openings in the roof surface, which are parallel with that surface, and which are for other purposes than the admission of light, such as scuttles, trap doors, etc., may be framed and finished in a manner similar to that just described for skylight openings.

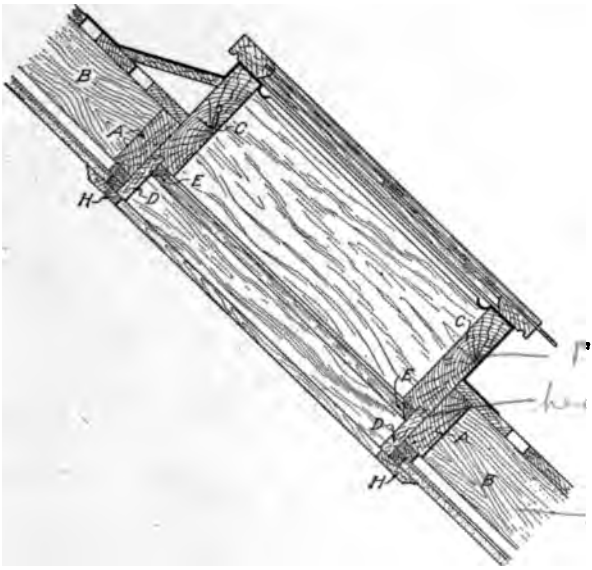

Fig. 292. Another Form of Skylight Construction

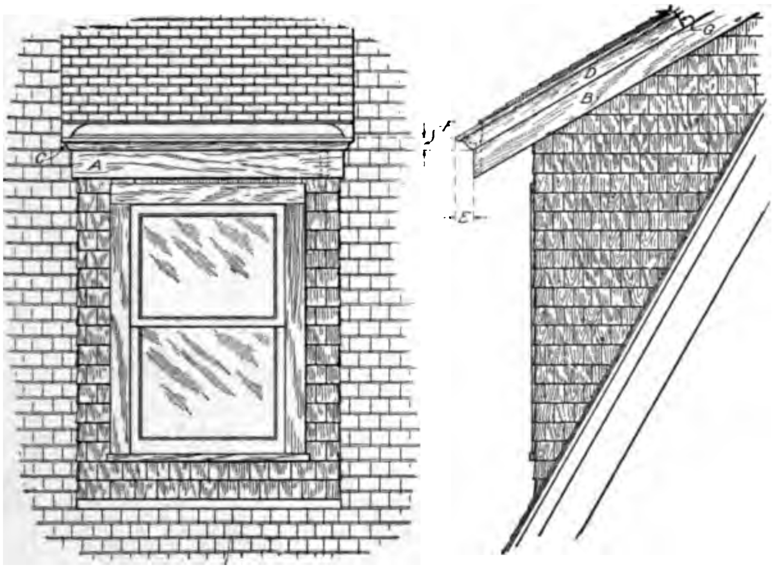

Fig. 293. Front and Side View of Simple Dormer Window

Dormer Windows. When it is desired to obtain the admission of light to the space under the roof surface in a way more elaborate and satisfactory than is possible with a simple skylight such as has just been described, recourse is had to dormer windows. They are so called probably because in early times nearly all of the sleeping-rooms of the houses were under the roofs and were lighted by means of such windows. They are formed by framing an opening in the roof surface in the same way as described for skylights, but on the rafters and on this framing are built up vertical walls of a height sufficient to take a small window set in vertically. The method of building the rough framework has been already described. The walls of dormer windows are treated in the same way as the walls of the main building, being covered with shingles or clapboards or, in some cases, with slates. Fig. 293 shows the most simple form of dormer-window roof. This is a simple roof with a pitch in one direction only, less steep than the pitch of the main roof so as to allow of enough vertical wall in the front part of the dormer to accommodate the window, and uniting with the main roof at a point farther up on this roof. The sides of the dormer are covered

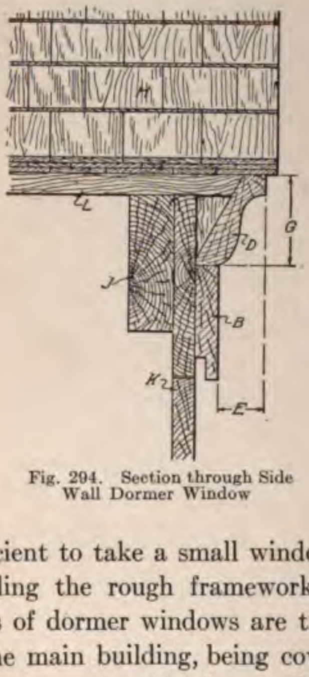

Fig. 294. Section through Side Wall Dormer Window

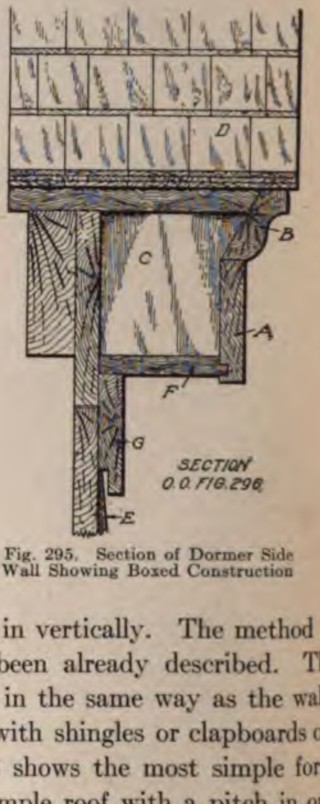

Fig. 295. Section of Dormer Side Wall Showing Boxed Construction

solid with shingles or whatever other covering is used, the front only containing an opening. This arrangement is the same for all dormer windows, there being no advantage in putting openings in the sides. The roof, shown in Fig. 293, sheds water onto the main roof in front of the dormer window and, therefore, there should be a gutter along this front and here the eaves should project somewhat over the wall, as shown. At the sides there need be no projecting eaves. A section through the gutter would be similar to that shown in Fig. 283, though the gutter itself may be a little smaller and the rafters are of course smaller. The piece marked *A* in Fig. 293 serves as a fascia to cover the ends of the rafters and this fascia should be continued up on the sides of the dormer as shown at *B* in Figs. 293 and 294. (Fig. 294 is a section to a larger scale through the side wall of the dormer window near the roof.) This fascia is cut out as shown, to receive the shingles which cover the side walls. The gutter marked *C* runs along the front of the dormer and should be made to miter at the end with a molded board marked *D*, which runs up on the side. A section through this molded board is shown in Fig. 294. The distance *E* in this figure must be the same as the distance *E* in Fig. 293, but as the distance *G* is not the same as the distance *F* (both in Fig. 293), the profile of the molded board *D* will not be the same as that of the gutter *C*. This is a principle which will often be met with in gable finish. In Fig. 294, *H* is the roof surface of the dormer, *J* is the end rafter, *K* is the boarding on the wall, and *L* is the boarding on the roof. If it is desired that the eaves shall project beyond the walls on the sides as well as on the front for the sake of effect or to better protect these side walls, this result may be accomplished, as shown in Fig. 295, by blocking out the fascia and the molded board as far as necessary. In this figure *A* is the fascia, *B* is the molded board, *C* is the blocking, and *D* is the roof surface of the dormer, *E* is the wall of the dormer. The blocking *C* should consist of pieces of 2-inch stuff cut to the required shape and spaced 1½ feet to 2 feet apart along the line of the eaves to receive the finished pieces *A* and *B*. *F* is a soffit piece added to box in the eaves and *G* is a secondary fascia added to receive the shingles or other covering.

The type of dormer roof just described throws the water forward onto the main roof of the building, but this arrangement may be varied by allowing the roof to drain sideways like an ordinary double-pitched gable roof. In this case there will be gutters on the eaves at the sides of the dormer window and a gable on the front. Such a window is shown in Fig. 296, in which *A* represents the line of the finished roof surface, while *B* is the roof of the dormer window shown in side elevation, *C* being the side wall of the dormer itself. *D* is the gutter at the eaves. A section through the eaves at *D* would be very much like that shown in Fig. 283. *E* is a fascia covering the ends of the rafters and the eaves may be either open or boxed in. The fascia *E* is usually continued around the front of the dormer window as shown at *F*, projecting as far as may be desired beyond the front wall *G*. A molded board, cut in such a way as to miter with the gutter, is carried up the side of the gable end, and this piece is generally known as a "raking molding," or a "raking mold." It is similar in shape to the molded board shown at *D* in Fig. 294. A section through the fascia where it runs across the face of the dormer is shown in Fig. 297. Here *A* is the fascia board which is nailed to the ends of pieces called "lookouts," about 2 inches

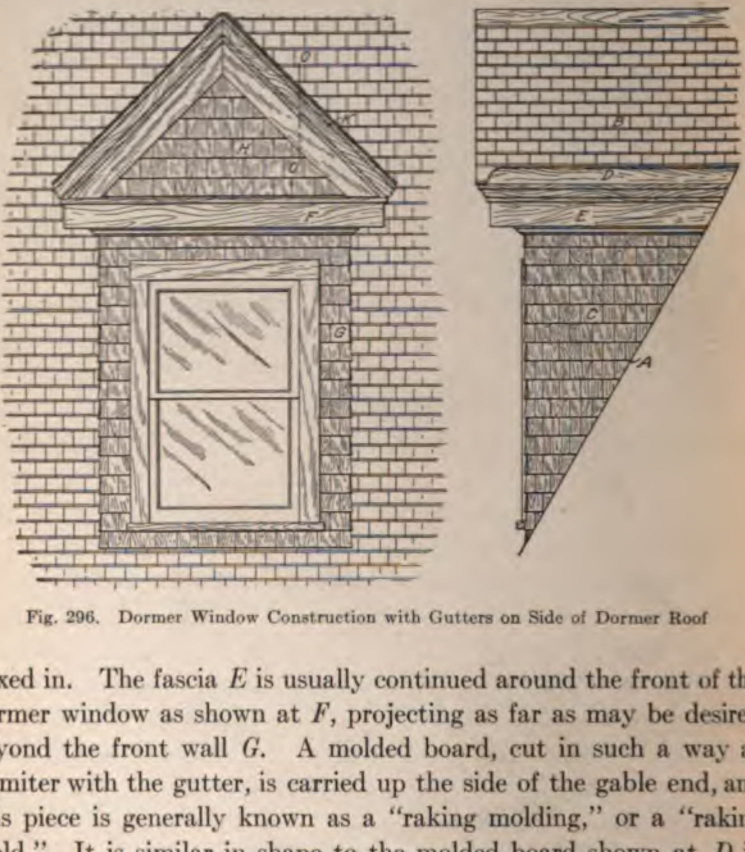

Fig. 296. Dormer Window Construction with Gutters on Side of Dormer Roof

thick and spaced from 1 to 2 feet apart, as shown at *B*. The lookouts may be nailed to the studs as shown in the figure or they may be merely nailed to the outside boarding, but the method shown is the better one, as it gives the lookouts a very much firmer support. The under side of the lookouts should be sheathed with ⅞-inch stuff as shown at *C*, with a piece *D* to receive the shingles. The upper surfaces should be covered also with sheathing and on top of this a covering of galvanized iron, copper, or tin to shed water. Besides this the tops of the lookouts should be cut with a pitch outward, as shown at *E*, to facilitate the shedding of water. In this figure, *F* is the studding and *G* is the outside boarding which comes in the triangular space marked *H* in Fig. 296. A section through the raking molding *K*, in Fig. 296, is similar to that shown in Fig. 295.

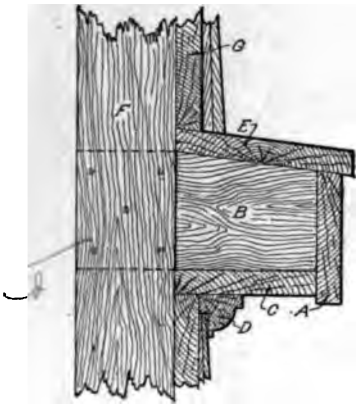

Fig. 297. Section Through Fascia Board

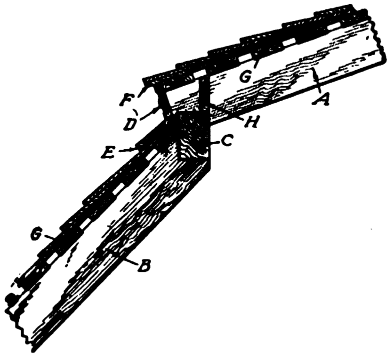

Fig. 298. Gambrel Roof Finish

Although the two types of dormer windows described are the basis from which all other types have been developed, still there are many kinds of dormers which have quite a different appearance. They are all, however, similar in construction to the two types shown, the difference being in the way in which the wall covering is applied and in variations in the proportion and in the shape of the windows. The ones shown are the very simplest of their respective kinds, but they serve to illustrate the manner in which all should be constructed.

Gambrel Roof Finish. The kind of roof known as a "gambrel roof" has already been described so far as the framing of the roof is concerned, but at the point where the steeper part of the roof meets the flatter part, there is a little finish which may well be described and illustrated while considering the roof finish. The rafters *B*, in Fig. 298, stop at the top against a framing piece *C* and the roof boards *G* are nailed to them, but the ends of the rafters of the flatter portion *A* rest on top of the piece *C* and the lower end would be left exposed if it were not covered by the finishing piece *D*. This is of ⅞-inch stuff and runs continuously across the ends of all the rafters, covering the spaces between them. It is well, however, to take the additional precaution of putting in the piece *H* so as to make the space under the roof less accessible to the weather. The shingles or other roof covering on the flatter portion of the roof should project over the piece *D* far enough to form a sufficient drip over it, as shown at *F*, and the piece *E* should be inserted to catch the drippings and shed them onto the shingling of the steeper roof.

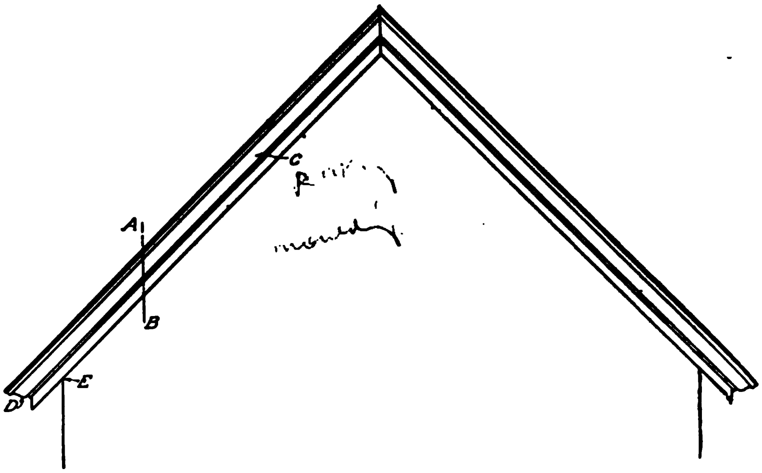

Fig. 299. Diagram of Simple Gable End of a Building

A form of finish similar to that described above may be used in the case of a deck roof at the point where the flat deck meets the inclined roof surface. The only difference between the deck roof and the gambrel roof finish shown in Fig. 298 is that the rafters *A* will be nearly flat instead of inclined, but this will not affect the application of the finish.

Gable Finish. We have seen that when a dormer window is designed with two sloping roof surfaces, there is thus formed on the front of the dormer a triangular-shaped surface which must be decorated in some way and which calls for a certain amount of finish. The same thing is true of the main roof when this is designed as a gable roof, the triangular surfaces at the ends of the building being known as "gables." The problem which presents itself here is to treat the lines in which the roof surfaces meet the vertical wall surfaces at the ends of the building, and to cover up the rough timber of both the wall and the roof. The most simple way of doing this is to miter the gutters at the sides of the building at the line of the eaves with a raking molding which will follow the line of intersection between the roof surfaces and the gable wall. In the plainest work

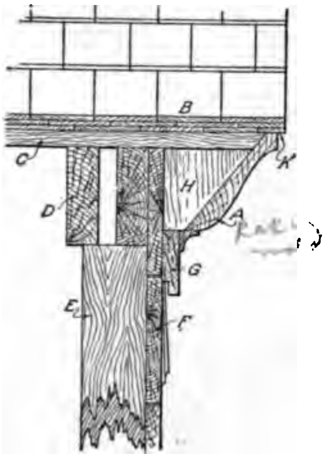

Fig. 300. Section through Raking Molding of Fig. 299.

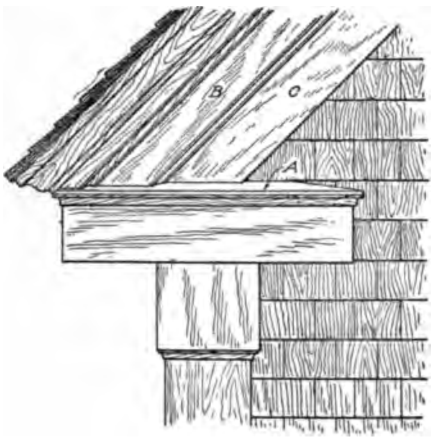

Fig. 301. Common Type of Gable Finish

this raking molding will not project much beyond the wall line, only far enough to miter properly with the gutter. Fig. 299 shows a very simple gable end of a building with no finish except the raking molding, referred to above, mitering with the gutter at the eaves. In this figure, *C* is the raking molding, *D* is the gutter. In Fig. 300 is shown a large-scale section taken through the raking molding where marked section *A-B* in Fig. 299. In Fig. 300 *A* is the raking molding, *B* is the roof shingling, *C* is the roof boarding, *D* the rafters, *E* the end studding, *F* the outside boarding on the end wall of the building, and *G* the fascia below the raking molding. The molding is so arranged that the roof boarding stops against it and the roof shingling passes over it and projects a little beyond it so as to form a drip as shown at *K* in Fig. 300. In the space marked *H* is blocking consisting of rough pieces spaced 2 to 3 feet apart and shaped to take the back of the molding.

There is an awkward place at the point marked *E* in Fig. 299, where the line of the gable meets the vertical line of the corner of the building, and some finish is usually placed here to overcome this awkwardness. In the small gable on the end of the dormer shown in Fig. 296 the fascia is carried across the face of the gable as well as along the raking line of the roof, and this arrangement is sometimes adopted on larger gable ends, but a more common practice is only to start the fascia across the gable end wall and then return it on itself a foot or two from the corner marked *E* in Fig. 299, stopping the raking fascia on top of it. This is shown in Fig. 301. A better result is obtained by returning the gutter molding as well as the fascia. The top of the return marked *A* in the figure should be sloped outward slightly so as to shed water. *B* and *C* are additional fascia boards which are added to give additional width to the raking moldings.

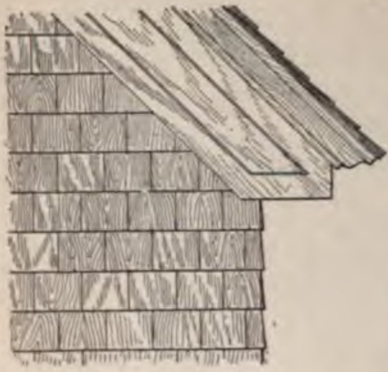

Fig. 302. Use of Verge Board as Gable Finish

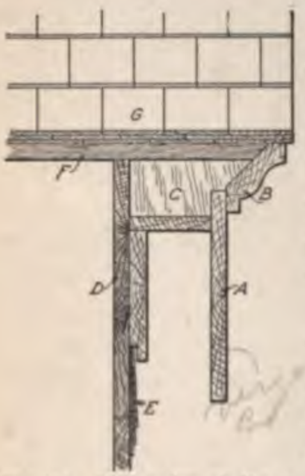

Fig. 303. Section through Verge Board and End Wall

Verge Boards. It is a common practice to use what are called "verge boards" for the finish of the gable ends of buildings. These are a kind of ornamental rafter which follows up the rake of the roof, not along the wall but some distance from it, being held in place by lookouts which are nailed to the studding or to the boarding and placed at the proper distances apart. The verge board forms a stop for the gutter and furnishes a very suitable finish for the gable. It is usually crowned with a raking molding of some sort and is, therefore, only a big fascia. Fig. 302 shows a verge board in elevation at the point where it joins the eaves, and Fig. 303 shows a section through the verge board and the end wall of the building showing how the board is supported by the lookouts. In this figure, *A* is the verge board, *B* is the raking molding, *C* is the blocking which forms the lookout, *D* is the outside boarding of the wall, and *E* is the shingling, *F* is the roof boarding, and *G* is the roof shingling.

WINDOW AND DOOR FINISH

Outside Finish around Windows. Wherever there is an opening in the wall of a wood building, such as a window or a door, the outside finish, consisting of shingling, clapboarding, or other covering, has to be cut through, and if no special provision were made for the finish around the opening there would be as a result a very ragged appearance. In order to avoid this it is customary to place all around the window opening pieces of finished timber which are known as *outside trim, outside architrave,* or *outside casing.* These pieces form a stop for the wall covering.

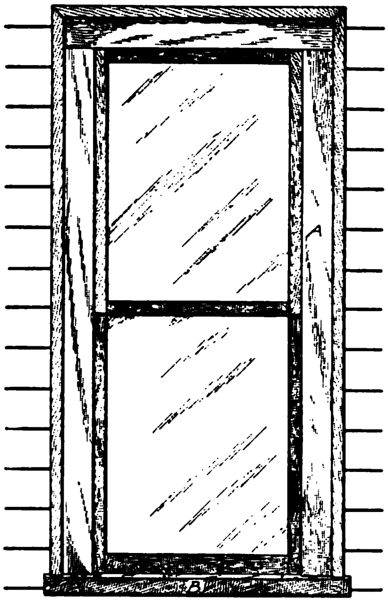

Fig. 304. Elevation of Window Showing Outside Trim

Fig. 304 shows a window opening in elevation looking from the outside and showing the outside trim. At *A* is shown the casing around the sides and head of the window and at *B* is shown the sill. In Fig. 305 is shown a section through the sill at the outside of the wall. Here, *A* is the sill itself which extends through the wall to the inside and receives the sash as will be explained later; *B* is the rough framing for the opening and this piece goes between the vertical studding at the sides of the rough opening; *C* is the outside boarding attached to the studding; *D* is the wall covering of shingles or clapboards; and *E* is building paper which must be placed between the outside boarding and the wall covering. It will be noticed that the under side of the sill is ploughed to receive the shingles or clapboards and that it projects out over the wall line a distance of about 1 inch, so as to let rainwater drip to the ground without touching the wall. This figure shows the simplest sort of sill, such as would be used only for very cheap work. In more important work it is customary to add another piece, called an "apron," under the projecting part of the sill, as shown in Fig. 306, where *A* is the apron, *B* is the sill, and *C* is the wall covering. The purpose of the apron *A* is to cover the joint between the wall covering and the sill and to give it a finished appearance. Fig. 307 shows a section taken through the side or jamb of the window shown in Fig. 304. Here, *A* is a section through the vertical studding at the sides of the rough opening, *B* is the outside architrave with the molding *C* attached to it, *F* is the outside boarding, *G* is the building paper, and *E* is the wall covering of clapboards or shingles.

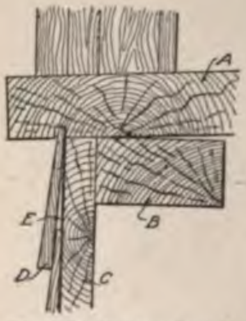

Fig. 305. Section through Sill at Outside of wall

header between sash

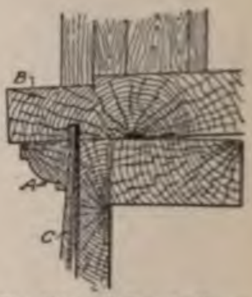

Fig. 306. Sill Details Showing Use of "Apron"

The outside architrave *B* is nailed at one side directly into the studding, and at the other side it is ploughed so as to join into another piece called the "pulley stile," the purpose of which will be explained later. This pulley stile must be placed at least 2¼ inches from the studding *A*, leaving a space marked *H* in the figure, which is called the "weight box" or "pocket," in which are placed the weights for operating the window. The arrangement of these weights will be explained in detail later. It will be seen that the width of the outside architrave *B* is determined by the width of the weight box which it has to cover. It will also be seen that the architrave *B* projects beyond the pulley stile *D* by a small amount at the point marked *K* in the figure. This projection is usually about ½ inch and is for the accommodation of the sashes. The purpose of the molding *C* is to form a projection against which the shingling or the clapboards can be stopped. The building paper *G* should be carried around as shown and the wall covering placed over it, so as to thoroughly cover the joint between the outside boarding and the molding *C*. This is to keep the weather from entering the building through this joint. If more room is required in the weight box this may be obtained by setting the outside architrave *B* outside of the outside boarding, as shown in Fig. 308. The molding *C* may then be dispensed with if desired, since it is no longer required as a stop for the wall covering, which can stop against the edge of the outside architrave *B*.

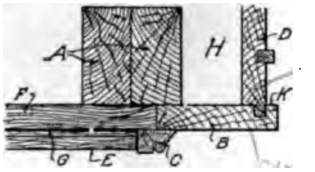

Fig. 307. Section through Window Jamb

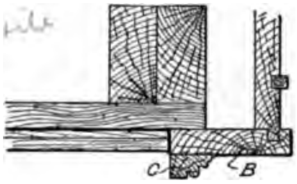

Fig. 303. Another Form of Window Jamb Construction

Pulley Stile. In Fig. 307 we have seen that the piece *D*, called the pulley stile, forms one side of the box where the weights for the window sashes are concealed, and that it is fastened to the outside architrave by a tongued and grooved joint. Besides forming one side of the box for the weights, the pulley stile acts as a guide for the sashes, which slide up and down in grooves formed by the outside architrave, the parting strip, and the stop bead, as is shown in Fig. 309. In this figure, which is a section taken horizontally through the window jamb, *A* is the pulley stile, which should be 1⅛ inch thick but may be made ⅞ inch thick if the windows are not large. *B* is the "parting strip," so called because it comes between the sashes and separates them from each other. It is let into the pulley stile as shown, and is usually ⅜ inch thick and about 1 inch wide. It must extend the full height of the pulley stile. *K* is the "stop bead," so called because it comes in front of the inside sash and holds it in place, forming one side of the groove in which the sash slides. The other side of the groove is formed by the parting strip, as shown in the figure. The stop bead is really a part of the inside finish, and is usually made of hard wood. It is screwed in place so that it can be easily removed, and when it has been taken out the sashes themselves can be removed also. The stop bead must be wide enough to go a little past the edge of the pulley stile and lap over onto the piece *L*, which is a part of the inside finish called the "inside architrave." The stop bead thus covers the joint between the outside and the inside finish. In Fig. 309 it will be seen that the outside architrave *C*, the parting strip *B*, the stop bead *K*, and the pulley stile *A*, together form a sort of pocket about the edges of the sashes *HH*, in which they slide up and down freely but out of which they can not fall either toward the inside or toward the outside of the building. Near the top of the pulley stile there is cut in it a mortise and in the mortise is placed a pulley about 2 inches in diameter, made especially for the purpose.

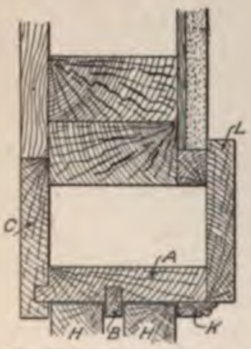

Fig. 309. Section Showing Pulley Stile Construction

A stout cord or chain is attached to the side of the sash and passes over the pulley into the weight box, where it is attached to a weight made of cast iron or lead which serves to balance the window sash and make it work more easily. There are two pulleys in the top of the pulley stile, one for each of the sashes. In Fig. 310, which is a view of the upper part of the pulley stile looking at its edge from the outside, one of the pulleys is shown at *A*. This figure also shows the top of the pulley stile *C* let into the yoke *G* about ½ inch. This is shown at *B*. It is the usual method of fastening the pulley stile at the top. In the figure *F* are the upright studs at the sides of the rough window opening, and *E* are the rough pieces which form the top of the rough opening. *D* is the parting strip at both the side and the top of the window opening.

In Fig. 311 is shown a section taken vertically through the top of a window frame of this type. *A* is the yoke, which should be 1⅛ inches to 2 inches in thickness; as explained above, it should be long enough to pass over the top of the pulley stile on both sides and allow this member to be let into it. The space *K* between the yoke and the rough framing *EE* is filled with rough blocking. *F* is an outside architrave similar in all respects to that which occurs at the sides of the opening. It is ploughed to receive the yoke, as shown. *B* is the parting strip, the same size as that on the pulley stile described above, and *C* is the stop bead. *L* is the inside architrave. *EE* is the rough framing between the studding at the sides of the opening, *G* is the outside boarding, and *H* is the plastering inside, *D* being what is known as a "ground."

Sill. In Fig. 312 is shown a section taken vertically through a window sill, showing the sill complete. Here *A* is the sill itself, which will be seen to extend through the wall far enough to receive the inside sash *G*. The top of the sill is cut with a slope downward and outward, which is known as a "wash," and the purpose of which is to carry off the rain water which may be driven against the glass of the window and drip down from there to the sill. *C* is the outside boarding, *B* is the rough framing, and *E* is the plaster. *D* is a part of the inside finish called the "stool" and *F* is another piece called the "apron," which together cover up the edge of the sill on the inside. The pulley stile is let into the sill about ½ inch in a manner similar to that in which it is let into the yoke at the top, and the sill is made long enough to extend a little beyond the back of the pulley stile on both sides just as is the yoke. Thus the two pulley

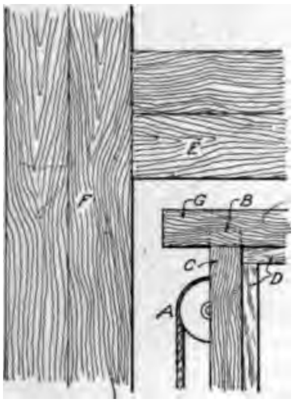

Fig. 310. View of Upper Part of Pulley Stile

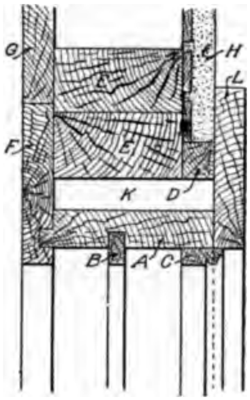

Fig. 311. Vertical Section of Top of Window Frame

stiles at the sides and the yoke at the top, together with the sill at the bottom, form a complete frame called the "window frame," which is usually made up at the mill and taken to the building in one piece, where it is set up in place inside of the rough-framed opening. The slight rabbet in the sill shown at *H* is intended for a stop for outside blinds when these are used. In this case the blinds are hung as shown in Fig. 313, which is a section taken horizontally through the window jamb. *A* is the outside architrave, which is placed in this case outside of the outside boarding *B* for the purpose of receiving the blinds. It serves at the same time as a stop for the wall covering *C*. *D* is the blind. and *E* is a piece put in to form the weight box and known as the "outside casing." This figure also shows at *G* a small block which may be inserted between the outside casing and the sash *F* in order to fill up the space and push the sash nearer the inside wall line. To this small block a strip may be nailed which will take a sliding fly screen.

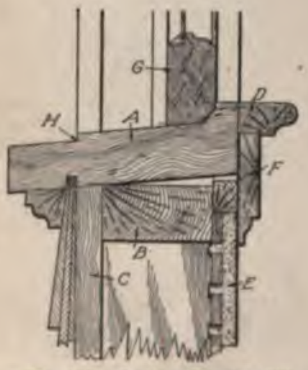

Fig. 312. Section Showing Sill Construction

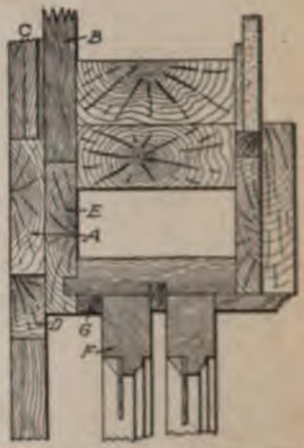

Fig. 313. Horizontal Section through Window Jamb

Double-Hung Sash. In Fig. 314 is shown a large-size section through the side or stile of an ordinary window sash, with some of the dimensions given. The same section is ordinarily used for the top rail of the sash, as for the stiles at the sides, but the bottom rail is usually made heavier. A section through the bottom rail is shown in Fig. 315. In Fig. 314, *A* is the body of the stile, which for ordinary

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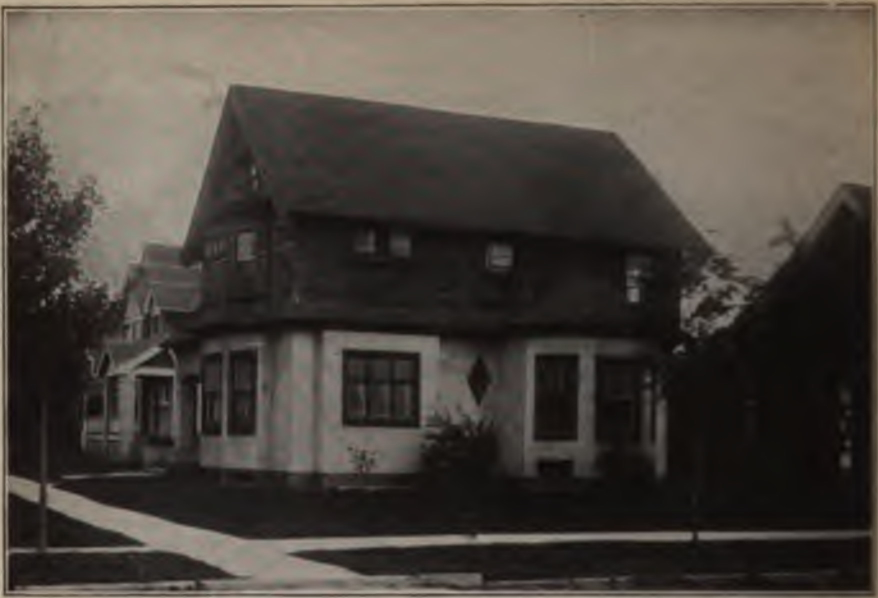


RESIDENCE FOR MRS. THOS. G. GAGE, ROGERS PARK, CHICAGO, ILL.

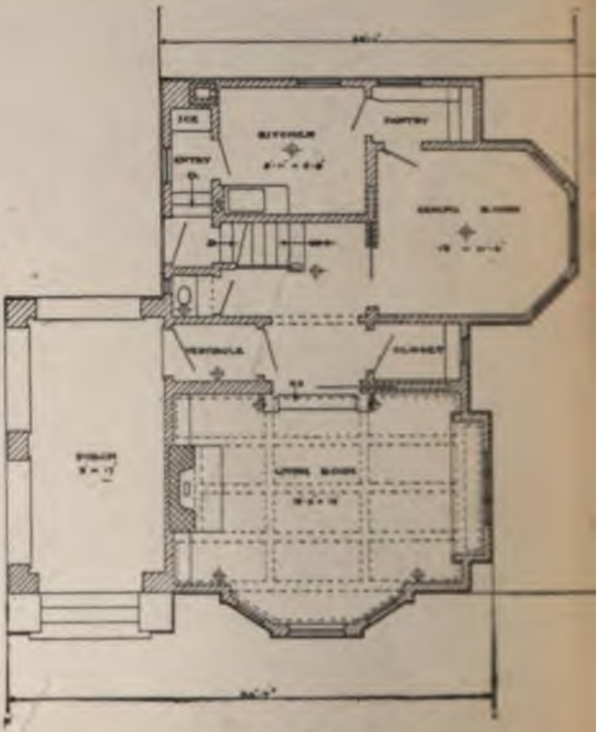
John B. Fischer, Architect, Chicago, Ill.

View Looking Southeast. Lower Story Cement, Rough Sand Finish; Second Story Finish Shingles Stained a Warm Brown; Woodwork around Windows and Gable Stained a Few Shades Darker than Shingles; Roof Shingles Stained a Dull Red.
For Interiors, See Page 251.

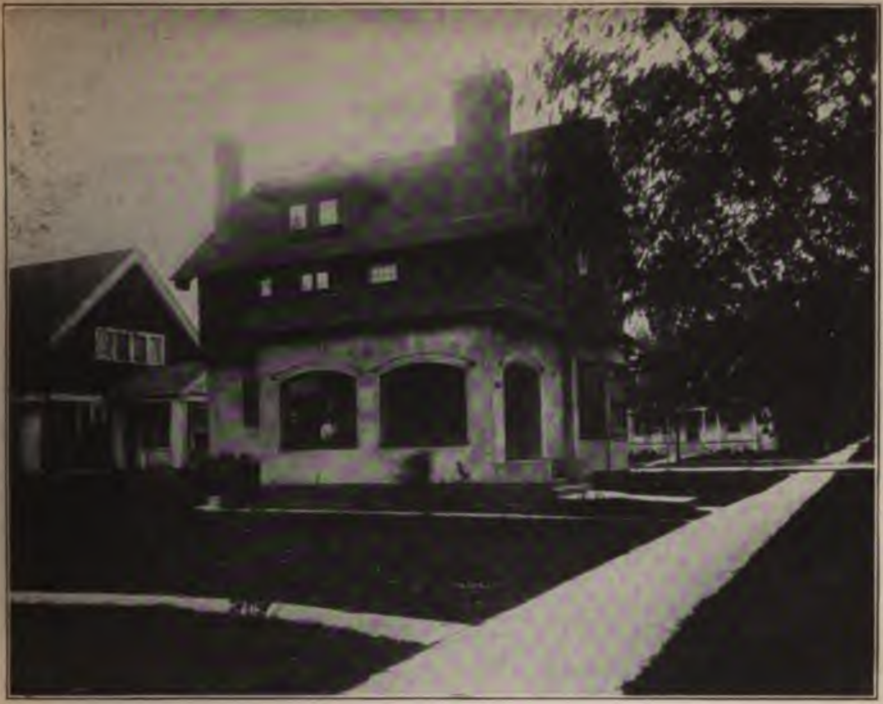
COST OF HOUSE:

Excavation	$ 27.50
Masonry	477.20
Carpentry	2,375.10
Sheet-Metal Work	70.00
Plastering	430.00
Plumbing and Gas fitting	450.00
Heating (Hot-Water)	449.40
Tile Work (3 Mantels, and Bathroom Floor)	193.60
Painting and Glazing	212.00
Hardware	60.00
Decorating	70.00
Electric Wiring	80.00
Electric and Gas Fixtures	83.20
Window Screens	20.00
Storm Sash	50.00
Window Shades	19.00
Cement Walk	23.00
Grading, Trees and Shrubs	72.00
Total	$5,162.00

Built in 1903.



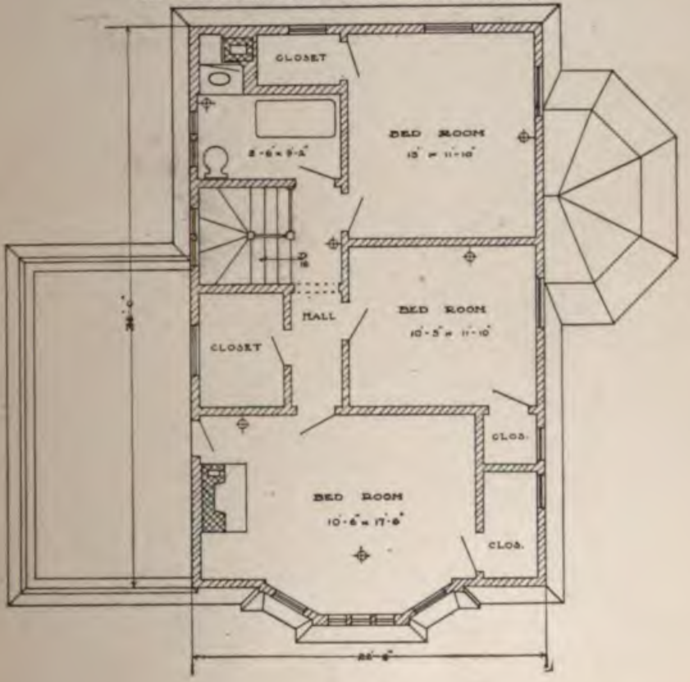
FIRST FLOOR PLAN



RESIDENCE FOR MRS. THOS. G. GAGE, ROGERS PARK, CHICAGO, ILL.

John B. Fischer, Architect, Chicago

The Porch Faces East toward Lake Michigan.



SECOND FLOOR PLAN

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ASTOR, LENOX AND
TILDEN FOUNDATIONS.

good work is made 1¾ inches thick and 2 inches wide, not counting the rabbet for the glass. This rabbet is shown at *C* and is made ⅜ inch × ⅝ inch, which makes the entire stile 1¾ inches × 2⅜ inches. The portion shown at *B* is molded in various ways, usually as shown. The glass *D* is held in place by means of small, triangular pieces of tin driven into the sash outside of the glass, after it has been put in, and then covered up with putty as shown at *C*. The bottom rail shown in Fig. 315 differs from the stiles only in size, being usually 3⅜ inches wide instead of 2⅜ inches.

Sashes are often made thinner than 1¾ inches, but if they are at all large they are likely not to stand well but will warp and twist. For very large windows the sashes should be made thicker still, being in this case 2 inches or even 2¼ inches thick.

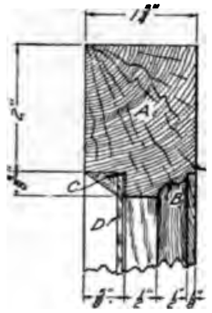

Fig. 314. Section through Window Stile

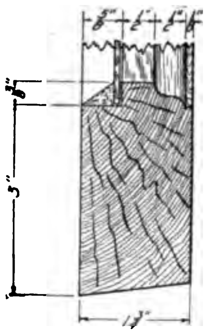

Fig. 315. Section through Bottom Rail

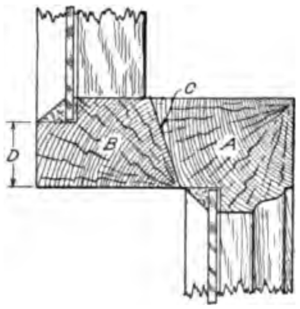

Fig. 316. Section through Meeting Rails of Window

Upper and Lower Sash. Double-hung sashes are divided into two parts, one called the "upper sash" and the other the "lower sash," which are so arranged as to slide by each other. They meet at the center of the window opening, and at this point, at the top of the lower sash and at the bottom of the upper sash, is a rail known as the "meeting rail." In Fig. 316 is shown a section through the meeting rails of a window. The section has been taken vertically and shows the meeting rails at a large scale. *A* is the top rail of the lower sash and slides up. *B* is the bottom rail of the upper sash and slides down, the two coming together in the inclined line marked *C*. Each rail is cut so that when they come together they will meet in this line. The thickness of the rails is determined by the fact that the distance marked *D* is 1 inch, making the entire thickness of the rail *B* 1⅜ inches and the thickness of the rail *A* 1¾ inches. The rail *A* is carried down below the bottom of the rail *B* so as to allow the glass to be puttied in as shown at *E*. In Fig. 317 is shown another method of fitting the glass into the top rail of the lower sash. Here *A* is the top rail of the lower sash and at *E* is shown the method of fitting the glass. As will be seen, the rail *A* is ploughed to a depth of about ¼ inch and the glass inserted in the opening. This method allows the rail of the lower sash as well as the rail of the upper sash to be only 1⅜ inches thick. Fig. 317 also shows another method of constructing the meeting rails as shown at *C*. Here, instead of meeting in a straight line as in Fig. 316, there is a slight rabbet made in each rail so as to give a small extent of horizontal surface on each. The advantage of this method is that it prevents the sashes from slipping too far past each other, as they may do if cut as shown in Fig. 316, especially after they have become a little worn.

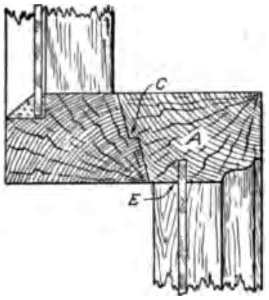

Fig. 317. Another Form of Meeting Rail

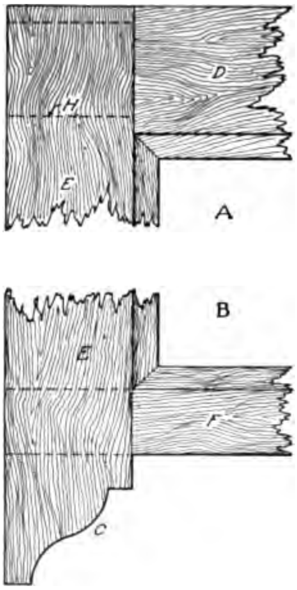

Fig. 318. Joint Between Stile and Rails

At the corners, where the horizontal rails meet the vertical stiles, they are fastened together with a mortise-and-tenon joint, the mortise being in all cases cut in the stiles and the tenon made on the ends of the rails. This is shown in Fig. 318 where at *A* is the joint between the top rail and the stile, and at *B* the joint between the meeting rail and the stile. *D* is the top rail and *E* is the stile, while at *H* is the tenon cut in the end of *D*, fitting into a mortise in *E*. *F* is the meeting rail tenoned into the stile. It is a common practice to continue the stile some distance below the meeting rail and to cut a molding in the end of it as shown at *C*. This makes the stile much stronger at this otherwise weak point. The joint between the bottom rail and the stile is made in a manner similar to that shown at *A*.

Muntins. When there are more than two lights in a window opening, the sashes must be subdivided and the panes of glass made smaller, and this subdivision is accomplished by means of pieces called "muntins" which are made so as to receive the glass in the same way as do the rails and stiles. In Fig. 319 is shown a window sash divided into lights, four in each sash, and at *A* is shown a muntin. In Fig. 320 is shown a full-size section through one of these muntins showing the way in which it holds the glass. *A* is the body of the muntin, *BB* is the glass on the two sides of it, held in place by the putty *CC*. The molding *DD* may be varied to suit the taste of the designer, but must be the same as on the rails and stiles.

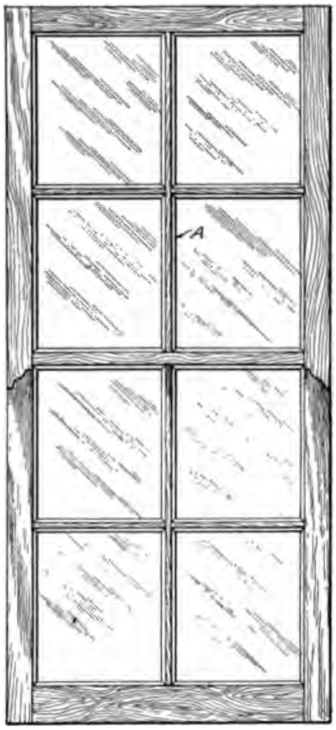

Fig. 319. Window Sash Showing Muntins

Casement Sash and Frames. The frames and the sash before described, known as "double-hung sash" or "English sash with box frames," are those most commonly employed in the United States and Canada, but there is another kind of sash known as "casement or French" sash which is constructed on a different principle entirely. This sash is hinged at the sides to the frame so as to swing either in or out. The principal objection to this arrangement is the difficulty of making such a sash water- and weather-tight. It is also impossible to use outside fly screens, if the sashes are hung to swing out, and if they are hung to swing in, the weather can penetrate through them much more readily. In Fig. 321 is shown a horizontal section through the side or jamb of a casement window in a frame wall. It will be seen that the outside architrave is similar to the one which was described in connection with the double-hung window, and in this respect there is no difference between the two. There is, however, no box for the accommodation of weights in this case, as no weights are required. The outside architrave is made in a way slightly different from any which have been illustrated before, but this method is equally well adapted for use with the other type of window. As shown at *H* it is made in two pieces, *H* being perfectly plain and the molded piece *K* worked out of smaller stuff and fastened on to it. It will be noted that the piece *K* is rabbeted slightly and that the end of the piece *H* fits into the rabbet in such a way that the joint between the two pieces is hidden from the front, and may open a little without being noticed.

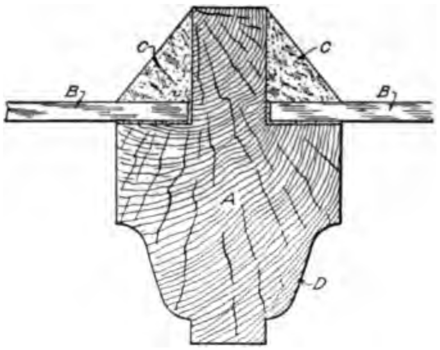

Fig. 320. Section through Muntin

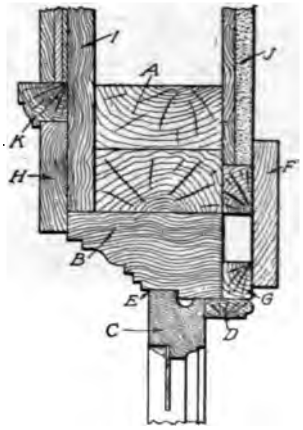

Fig. 321. Horizontal Section through Jamb of Casement Window

In the figure, *AA* are the studs at the sides of the opening, *I* is the outside boarding and *J* is the plastering on the inside. *B* is the frame for the casement window, which in this case is made very thick, $2\frac{1}{4}$ to $2\frac{3}{4}$ inches in thickness, rabbeted $\frac{1}{2}$ inch, as shown at *E*, to receive the sash *C*. The sash itself is rabbeted and a groove is cut vertically in it, as shown, in order that any rain water which may penetrate the joint at *E* may be stopped and may run down the groove to the sill without getting inside. *D* is the stop bead and *G* is a block which receives the inside architrave *F*. The sash is hinged at the point *E* and swings out. In Fig. 322 is shown another method of constructing a casement window so that the sash will swing outward. In this case the sash is placed much nearer the outside of the frame and the frame is made much lighter than in the design shown above. The frame *B* is made from stuff only 1¾ inches thick and is made wide enough to extend in to the plaster line, thus doing away with the block *G* in Fig. 321. The stop bead *D* is also omitted. The frame *B* is rabbeted near the outside edge to a depth of about ¾ inch to receive the sash *C* and an extra groove is cut in the frame to receive a half-round molding cut in the edge of the sash. This arrangement is to keep out the weather. The sash *C* is 1¾ inches thick and 2⅜ inches wide. There are, of course, many other ways of constructing these frames and sashes which are more or less elaborate, according as the work is intended to be cheap or good. The designs shown are suitable for ordinary, good work and may be simplified for cheap work.

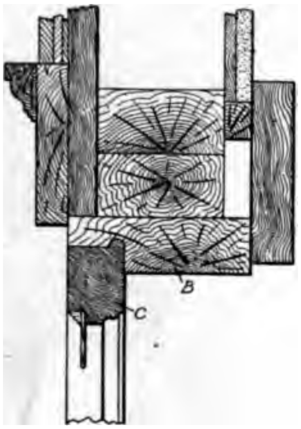

Fig. 322. Another Form of Casement Window Construction

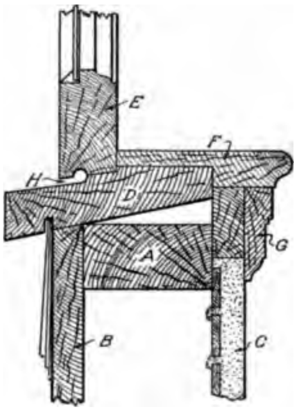

Fig. 323. Vertical Section through Sill of Casement Window

Fig. 323 shows a section taken vertically through the sill of a window of the casement type, which opens out. *A* is the rough piece which forms the bottom of the rough opening, *B* is the outside boarding, *C* is the plastering. *D* is the sill, and *E* is the sash. *F* and *G* are the inside finish which cover up the rough sill *D*. It will be seen that the sill *D* is ploughed on the under side to receive shingles, as was the sill of the double-hung window. It is rabbeted on the top to receive the sash *E*, and rabbeted again under the sash so that there will be less chance that the drippings from the sash will be driven into the inside by the wind. The under edge of the sash is also ploughed as shown at *H* in order to catch these drippings if they are blown in. This sill is for a sash which is placed near the outside of the frame, while Fig. 324 shows a sill suitable for a sash placed, as shown in Fig. 321, nearer the inside of the frame. In this figure, *E* is the sash and *D* is the sill.

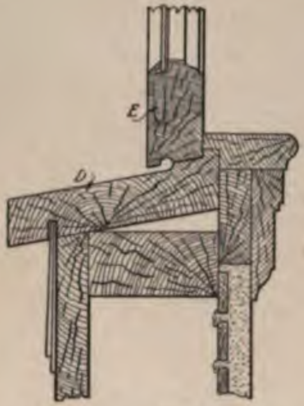

Fig. 324. Another Type of Sill Construction

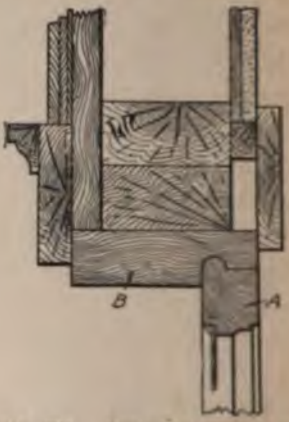

Fig. 325. Horizontal Section of Casement Window Opening In

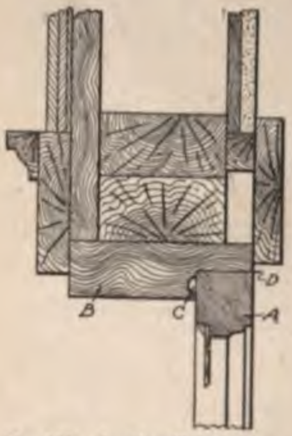

Fig. 326. Another Construction Similar to Fig. 325.

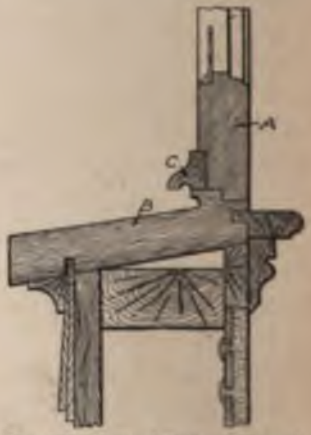

Fig. 327. Vertical Section Through Bottom of Casement Window Opening In

The casement windows so far described are for sashes which are made to open out, but casements are also made to open in. Fig. 325 shows a horizontal section through the jamb of such a window frame and sash. *A* is the sash with a half-round fitting into a mortise in the frame which is rabbeted as well to receive the sash. *B* is the frame, the sash being placed on the inner edge of the frame. Another method of forming the frame is shown in Fig. 326. Here, as in Fig. 325, *A* is the sash, and *B* is the frame which is ploughed as shown at *C*. This allows the sash to be made without the tenon shown in Fig. 325 and is, therefore, cheaper and easier to make as regards the sash without being any more expensive as regards the frame. The hinges in this case come at the point marked *D* and they would come in the same position in Fig. 325. In Fig. 327 is shown a vertical section through the bottom of a casement window opening in. It will be seen that the sill *B* differs but little from the other sills shown before. It is rabbeted on the inside for the reception of the sash *A*, and at *C* is shown a special drip piece which is let into the sash and which is ploughed on the bottom so as to receive any drops of water which may be blown under it by the wind. All casement sashes opening in should be provided with something of the kind.

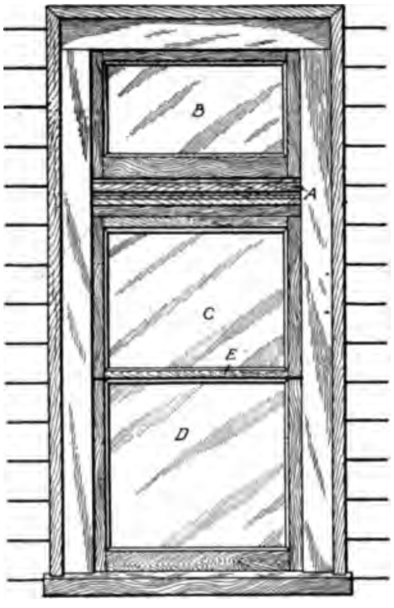

Fig. 328. Elevation of Double-Hung Window with Transom

Transoms. It is often desirable to separate the lights of a window, whether it is a double-hung window or one of the casement type, by means of a horizontal division called a "transom." In this case the additional light which comes above the transom is in the nature of an extension to the window proper, and it is usually hung in a different way, sometimes being made stationary so as not to be allowed to open at all. Fig. 328 shows a double-hung window with a transom and a transom sash. *A* is the transom, *B* is the transom light, *C* is the upper sash of the window proper, *D* the lower sash, and *E* is the meeting rail. In Fig. 329 is shown a casement window with a transom, *A* being the transom, *B* the transom light, *CC* the two lights of the window proper which are hinged at the sides, and *D* the meeting stile. As no description of the meeting stile for casement windows has yet been given, a section through the stile is shown in Fig. 330. The bead at *AA* may be omitted if desired and the stiles may be made plain. This, of course, cheapens the construction somewhat.

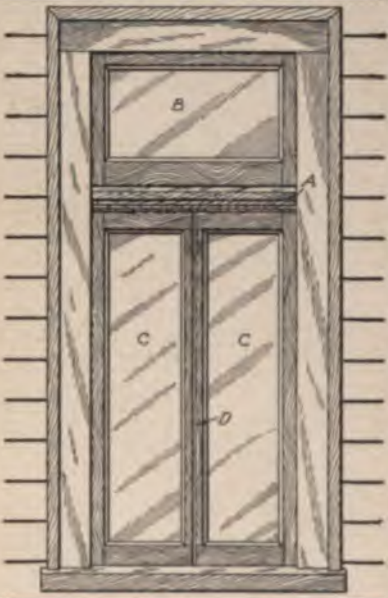

Fig. 329. Casement Window with Transom

A transom for a double-hung window must combine two members, namely, a headpiece for the window proper, and a sill for the transom sash to stop against. These properties determine the construction of the transom. In Fig. 331 is shown a section taken vertically through the transom of a double-hung window, and it will be seen that the two members have been provided for. *A* is the sill for the transom sash, which is shown at *C*, while *B* is the head jamb for the main window frame, the upper sash being shown at *O*. The piece *D* is in line with the outside casing of the window at the jambs, and *E* is the stop bead which is in line with the stop bead at the sides. The space marked *H* is filled with blocking. *G* is the window stool on the inside and *F* is the finished face of the transom on the inside.

In Fig. 332 is shown a section taken vertically through the transom of a casement sash such as is shown in Fig. 329. It will be seen that this transom differs somewhat from the transom shown in Fig. 331, the head for the casement frame being quite different from the head for a double-hung window frame.

In this figure, *A* is the top rail of the lower part of the window, that is, of the casement sash itself, while *D* is the bottom rail of the transom sash which forms the upper part of the window. At *H* is shown a small groove in the top rail, which is intended to catch any water which may be driven through the opening between the sash and the frame during heavy rains. This groove should be deeper at one end of the top rail than it is at the other end, so that the water will flow away toward the side and be carried down to the sill, which will throw it outward. *E* is the stop bead immediately inside of the casement sash. *B* is the piece which forms the head of the casement frame, and is the same in outline as the pieces which form the jambs. On top of the piece *B* is the sill *C* of the transom frame, and the two are placed close together so as to form really one solid transom. The sill piece is made with a wash on top, the slope of which should be about 2 inches to the foot, and on top of the sill piece comes the lower rail of the transom sash *D*. The piece *F* is a stop bead carried across the frame on the inside just above the sill piece for the transom sash to stop against in case it is hinged at the top to swing outward, or to receive the hinges in case it is hinged at

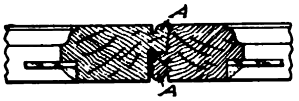

Fig. 330. Section through Casement Meeting Stiles

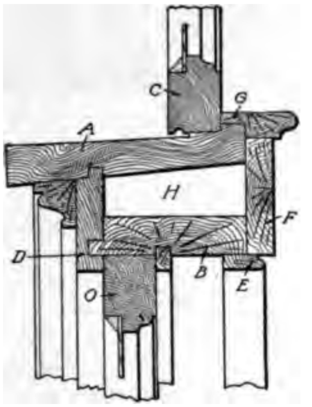

Fig. 331. Vertical Section through Transom of Double-Hung Window

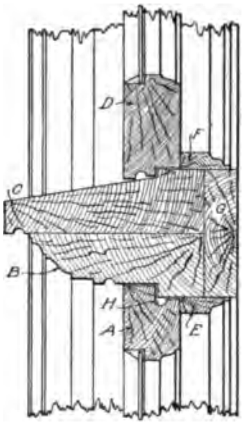

Fig. 332. Section through Transom of Casement Window

the bottom to swing inward. The latter arrangement is the most common one. The piece *G* forms the inside finish of the transom bar and may be treated in any way desired.

Mullions. In Fig. 333 is shown a double-hung window which is in two parts with a mullion between them. The mullion is shown at *A*. The window shown also has two transom sashes with a mullion between the sashes *BB* and the mullion at *C*. The mullions *A* and *C* are usually made 8 or 9 inches wide, so as to provide space for the weight boxes in the thickness of the mullion. Fig. 334 shows a section taken horizontally through the mullion *A*, with spaces for the weights at *DD* and with a strip *E* to separate the two weight boxes. *FF* are the two pulley stiles, made in the usual way as described above, with parting beads at *GG* and the sashes at *HH*. *K* is the piece which forms the outside finish of the mullion and helps

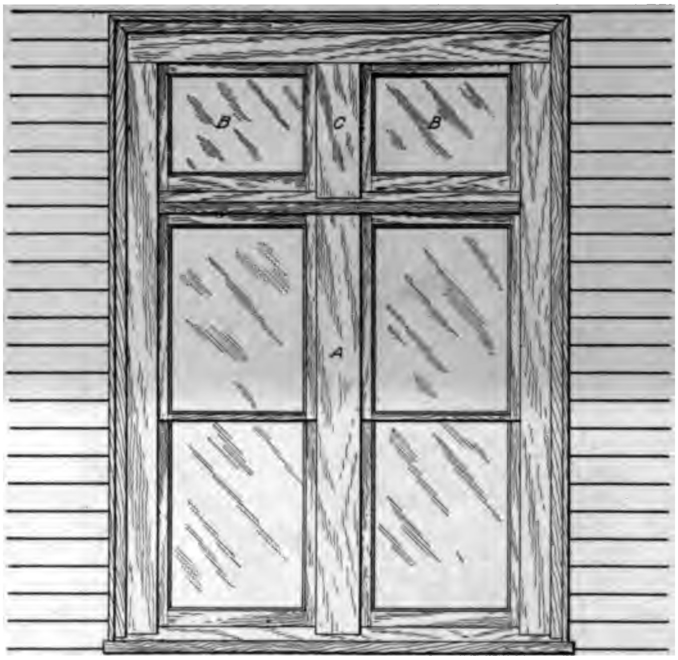

Fig. 333. Double-Hung Window in Two Parts with Mullion Between

to form the enclosed weight boxes, with the pulley stiles grooved into it as shown. The piece *L* forms the inside finish of the mullion and the inside wall of the weight boxes and may be made very plain or very elaborate to suit the taste of the designer. It may be treated with sinkages or with raised moldings and varied to almost any extent. *MM* are the stop beads which hold in the sashes and serve also to cover the joint between the pieces *FF* and the piece *L*.

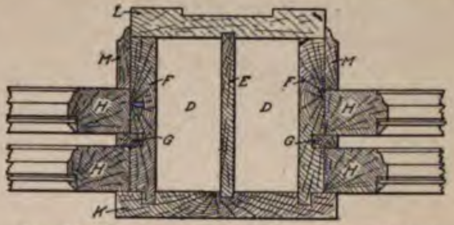

Fig. 334. Horizontal Section through Mullion of Fig. 333.

In Fig. 335 is shown a casement window with a mullion. The mullion is seen at *A*. It will be noticed that it is much narrower than the mullion used in the case of the double-hung window shown in Fig. 333, the reason for this being that in the case of the casement

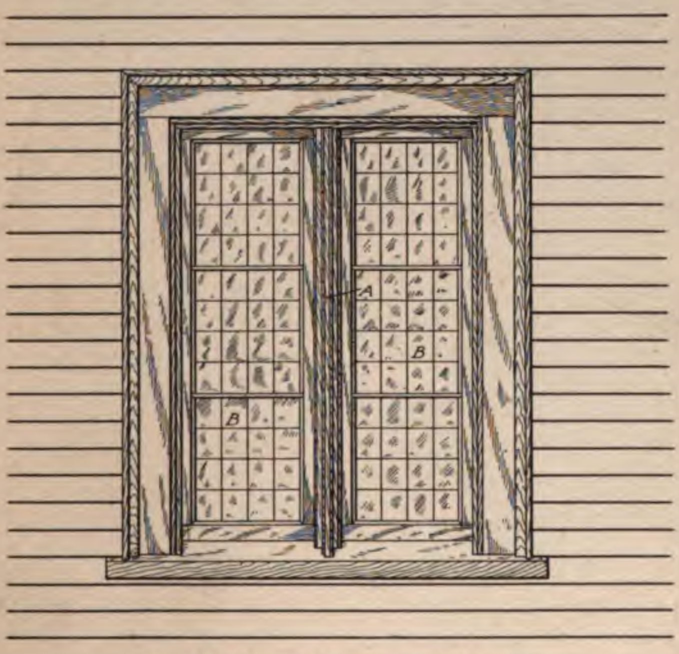

Fig. 335. Casement Window with Mullion

window there are no weights to be taken care of and so there need not be any weight boxes in the thickness of the mullion.

BB are the casement sashes which are in this case filled with leaded glass. They should be hinged at the sides to open inward or outward stopping against the mullion. In Fig. 336 is shown a section taken horizontally through the mullion *A*, showing its construction. The sashes are shown at *CC* and are intended to open out. They are grooved to prevent the rain water from penetrating to the inside and are rabbeted so as to further keep out the weather. The mullion itself is shown at *D*. It is built up out of three pieces which may be molded to suit the taste, but there must always be a rabbet for the sash to stop against. *E* is the piece which forms the inside finish of the mullion and *FF* are the stop beads.

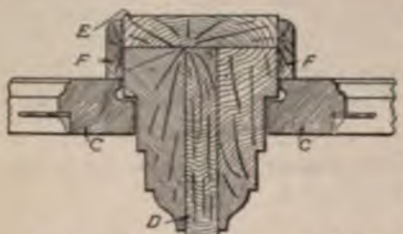

Fig. 336. Mullion Construction for Fig. 335

Windows in Brick Walls. Windows in brick or other masonry walls are in every respect similar to windows in frame walls, the only difference being in the arrangement of the jambs, heads, and sills. Fig. 337 shows a section taken horizontally through the jamb of a double-hung window in a brick wall. At *A* is shown a section through the wall itself. It will be seen that there is a sort of rabbet made in the back part of the wall in which to set the window frame, and that the front portion of the wall projects in front of the frame. This is done in order that there may be a certain amount of solid masonry which will cover the joint between the wall and the frame and prevent the wind from driving in between them through this joint. The distance *B* is called the "reveal" of the window, and is usually made 4 inches, but is sometimes 8 inches. The depth of the

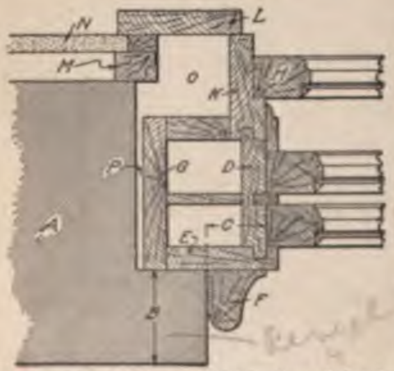

Fig. 337. Horizontal Section through Jamb of Double-Hung Window in Brick Wall

rabbet in which the frame sets may vary considerably, but is usually 2 to 4 inches.

From the face of the brick reveal to the face of the pulley stile *D* the distance *C* may be made anything, according to taste, but is best made about 2 inches. The pulley stile *D* is made in the same way as for windows in frame walls. *E* is the outside casing, which sets as close as possible against the brickwork, and *G* is a piece called the "back lining," which forms the back of the weight box. In all other respects the construction is the same as described for windows in frame walls. At *H* is shown an inside sash which can be put on in winter for additional protection against the cold. It is usually made as a casement sash to open in. As will be seen, it is hung on a rabbeted piece *K*, which also forms the jamb lining of the window on the inside and receives the inside architrave which is indicated at *L*. *M* is the furring on the inside of the brick wall and *N* is the plastering. The space *O* is filled with rough blocking, and the space *P* should be well caulked with oakum, or other substance, to keep out the cold. *F* is a piece called a "brick mold" or sometimes, a "staff bead," which is put in to cover up the joint, between the frame and the brick. It may be of any desired form, being sometimes made a simple square block or strip on which the window blinds are hung.

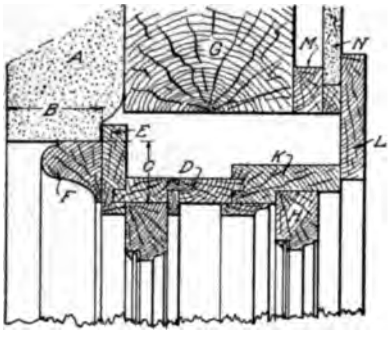

Fig. 338. Section through Head of Double-Hung Window

Fig. 338 shows a section taken vertically through the head of a double-hung window in a brick wall. At *A* is the masonry lintel which covers the masonry opening. It is usually of stone. The distance *B* is the same as the distance *B* in Fig. 337 and the distance *C* is also the same as the corresponding distance in Fig. 337. *D* is the yoke, the same as for a window in a frame wall, with the outside casing *E* and the staff bead *F*. *G* is the wood lintel which is usually placed behind the stone lintel over the masonry opening. This section also shows an inside or winter sash at *H*, the same as in Fig.

337, with the piece *K* arranged to receive it and also to receive the edge of the inside architrave *L*. *M* is the furring on the masonry wall, and *N* is the lathing and plastering, the plastering being covered by the architrave *L*.

Fig. 339 shows a section taken vertically through the sill of a double-hung window in a brick wall. *A* is the stone sill in the outside of the masonry wall, and should be wide enough to extend into the wall and under the wood sill far enough to allow the latter to lap over it about 2 inches. The wood sill, shown at *B*, is usually made wide enough to receive the staff bead, so that the width of the stone sill needs to be about the same as the depth of the reveal at the jambs, or the stone lintel at the head of the window. The sill *B* rests, on the inside, on a piece of rough timber built into the wall, as shown at *D* in the figure. The sill should have a "wash," or slope outward and downward, of about 1½ inches to the foot. In the figure, *C* is the lower rail of the lower sash of the window, which must stop against the sill and be made tight in some way. The figure shows both the sill and the sash rabbeted, but very often the sash is not rabbeted. The piece *E* forms the finish on the inside corresponding to the stop bead at the jambs and head, and serves to cover up the rough sill. The piece *F* also serves the same purpose. *L* is the rough brick wall with the furring at *M* and the plastering and lathing at *N*, and the space between the rough sill and the plastering is covered and finished by the piece *G*, or the stool. Underneath the stool is placed the apron, as shown in the figure at *H*.

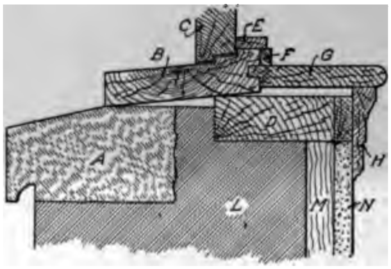

Fig. 339. Vertical Section through Sill in Brick Construction

Outside Door Frames. Outside doors are usually made heavier and thicker than inside doors, and, therefore, the frames for them must be different from the frames for inside doors even in frame buildings, and in buildings of brick or stone they are necessarily different from the inside door frames on account of being set in the masonry walls, while the inside door frames are usually set in wood walls. The interior partitions of large buildings, however, are frequently made of terra cotta blocks or of plaster on wire lath, but the door frames which may be used in these cases are essentially the same as those used for openings in stud walls.

The jambs and head of the frame, if in a building of wood construction, are usually made of plank from $1\frac{3}{4}$ inches to $2\frac{1}{4}$ inches thick. As the doors to private houses generally open inward, the frames must be rabbeted on the inside edge to receive the door, and should also be rabbeted on the outer edge to receive a screen door in summer. The inner edge of the frame is set flush with the plaster line in the inside so as to receive an architrave, the same as in the case of a window frame.

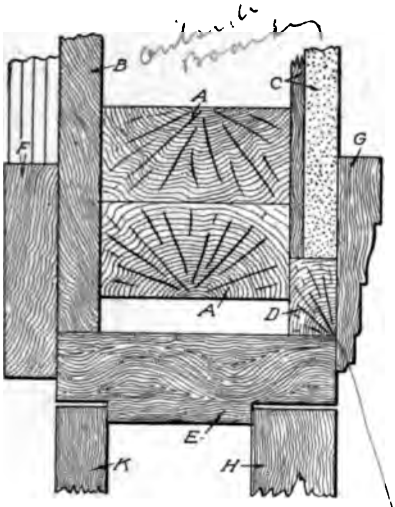

Fig. 340. Section of Outside Door Frame

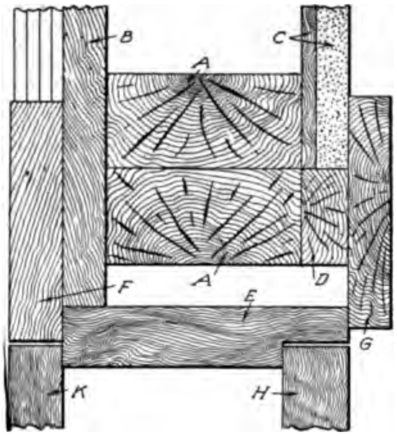

Fig. 341. Another Outside Door Frame Construction

Fig. 340 shows an outside door frame for a wood building. *AA* are the studs which form the rough opening, the section being taken horizontally through the door jamb. *B* is the outside boarding and *C* is the lathing and plastering which is carried on the inside of the studding.

It will be seen that the frame *E* extends in width from the outside of the boarding to the inside of the plaster, and receives on its outer edge the outside casing *F*, and on its inner edge the inside architrave *G*. *D* is a ground for the plastering, and *H* is the door itself, fitting into a rabbet cut in the frame, about $\frac{1}{2}$ inch deep and the thickness of the door. *K* is the screen door for which a rabbet is cut in the outside edge of the frame.

A similar arrangement is shown in Fig. 341. There is no rabbet cut in the frame shown in this figure, the screen door being designed to hang on the edge of the outside casing, as indicated, the casing being made thicker in order to receive the door. This figure is lettered the same as Fig. 340.

The section taken vertically through the head of the door frame would be the same as the section through the jamb, but the section taken through the sill would be different. Fig. 342 shows such a section. Here, *A* is the sill which forms a part of the rough framing of the building, and rests on the foundation walls, receiving the joists which are shown in the figure at *B*. *L* is the line of the outside boarding, *C* is the under flooring, and *D* is the finished flooring. On top of the under flooring is placed the door sill *E*, which is cut out of plank about 1¾ to 2½ inches thick, with a wash on the outside like a window sill, and with the top placed about ¾ inch above the finished floor so as to allow the door *F* to swing inward over any rug or carpet which may be laid on this floor. The sill is a little wider than the distance from the inside of the inside architrave, to the outside of the outside casing. The line *H* is the line of the porch floor, if there is any porch, or there may be a step with the face as indicated by the line *K*. *G* represents a screen door.

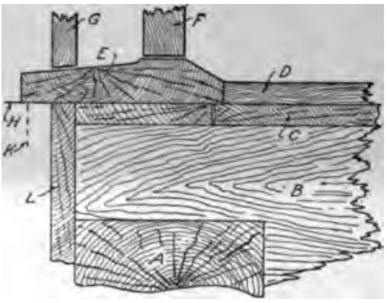

Fig. 342. Section through Sill of Door Frame

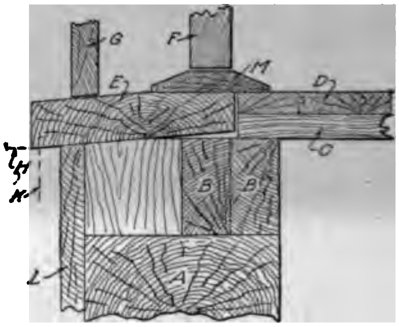

Fig. 343. Another Type of Construction for a Door Sill

Fig. 343 shows another type of door sill which is more simple in construction and less expensive than that shown in Fig. 342.

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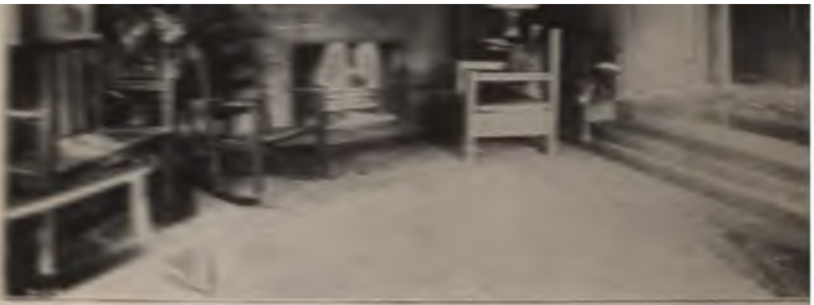


East End of Living Room

The Mantel is Faced with Green Unglazed Tile. Flat-Sawed Oak Finish, Stained Brown Waxed; Plaster Work, Rough Sand Finish, Painted.

Instead of being shaped to receive the door, as is the sill shown in Fig. 342, it is cut square, with a slight wash only, and on top of it is placed a saddle under the door. In Fig. 343 *A* is the rough sill of the framework resting on the foundation walls; *BB* are blocks to receive the ends of the flooring *C* on top of which is the finished flooring *D*. The top of the sill *E* is flush with the top of this finished flooring, and the saddle *M* covers the joint between the two, being beveled as shown at both sides. *F* is the door, and at *G* is the outside screen door. As before, *H* is the level of the veranda, if there is one, and *K* is the face of the riser of a step which may be placed under the sill on the outside. *L* is the line of the outside boarding.

Inside Door Frames. Inside door frames are in some respects similar to the outside door frames described above, but as they are intended for the lighter interior doors, they are not made so heavy as are the outside frames. Fig. 344 shows a section taken horizontally through the jamb of an interior door frame, the same section also serving for a section through the head of the frame taken vertically since the two sections will be the same. In this figure, *AA* are the studs in the partition at the side of the door opening, and forming the rough framing for the opening. *BB* are the grounds for the plaster *C* to stop against, and these grounds, of course, go all around the door opening, on both sides, and across the top. *D* is the finished door jamb, the head being exactly the same in section. The jambs are usually made 1⅛ inches thick, but sometimes only ⅞ inch. *F* is the door itself, shown 1¾ inches thick, although closet doors are frequently made of less thickness than this, and some heavy doors might be thicker. At one side of the frame the door is hinged, the hinge being fastened partly to the edge of the door, and partly to the frame, but at the other side of the frame there must be something provided to form a stop for the door. There are several methods of applying the "stop," one of which is shown at *E* in the figure. It is fastened to the jamb, but is in the form of a separate piece. The stop is carried all around the door

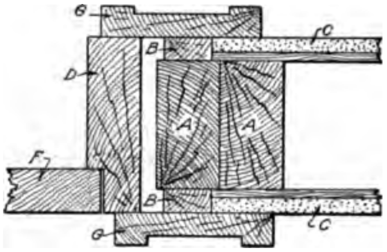


Fig. 344. Horizontal Section through Jamb of Interior Door Frame

opening, and is usually set back from the edge of the jamb on both sides by an amount equal to the thickness of the door, so that the door can be hung at either edge of the jambs, or at either side of the partition. The final finish of the door opening is the "architrave" or "casing," which is shown at *GG*. This must be at least wide enough to extend from the edge of the jamb over onto the plaster so as to cover the joint entirely.

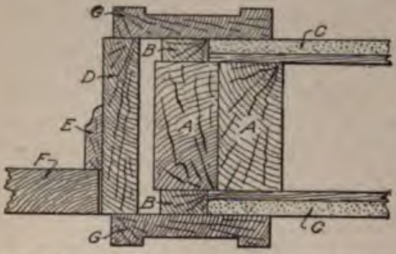


Fig. 345. Another Door Frame Construction

Another method of making the door frame is shown in Fig. 345. Here, the frame is rabbeted to form a place for the door, and there is no need of a stop. Such a frame is usually made thicker than the one shown in Fig. 344, and is rabbeted to a depth of $\frac{1}{2}$ inch, and the thickness of the door. The principal objection to this method is that at the head of the door, which is rabbeted the same as is the jamb, the part of the frame which shows above the door itself is greater on one side of the door than it is on the other. Therefore, unless all the doors in a room open into that room, or all of them out from the room, they will not line with each other at the head. For this reason it is better, to use some form of frame with a separate stop planted onto it, or a frame rabbeted on both sides.

The lettering in Fig. 345 is the same as in Fig. 344, and need not be explained again.

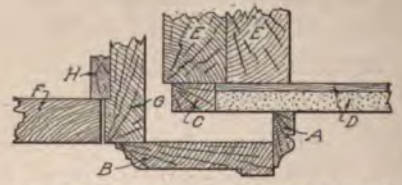


Fig. 346. Door Trim Construction Showing Back Band

The only finish about a door frame with the exception of the door itself, is the architrave or the trim as it is sometimes called. It is also called casing. This is shown at *G* in Fig. 344. It may be made of any design desired, and as wide as desired, it being only necessary that it shall cover the plaster ground *B*, and project over onto the plaster *C*. The architrave is usually worked out of $\frac{7}{8}$-inch stuff, but may be made thicker as necessary. Its thickness is determined by the thickness of the base or skirting in the room, which base or skirting has to stop against the architrave at each side of the door opening.

In Fig. 346, at *A*, is shown what is known as a "back band." It goes behind the architrave, as shown, and is used when for any reason it is necessary to have the architrave set out from the face of the plaster. Its purpose is to cover up the joint between the architrave and the plaster surface. Of course it may be molded as desired. It is usually made $\frac{5}{8}$ inch thick and as wide as necessary. In Fig. 346 *B* is the architrave, *C* the plaster ground, *D* the lathing and plastering, *EE* the studding in the wall, *F* the door, *G* the jamb, and *H* the stop. It will be seen that the stop *H* is set into the jamb *G*. This makes a good, solid construction, but it is not often done on account of the trouble and expense involved.

Doors. The construction of doors is essentially the same, whether they are to be used as outside or as inside doors, the only difference being in the thickness of the door and in the finishing of it. The most simple kind of door is, of course, a single piece of board, with hinges at the side, but this is almost never satisfactory for any purpose, as it is likely to warp, crack, and shrink, and has not sufficient strength. It is customary in every case to build up a frame of comparatively heavy pieces and then to cover it over or to fill it in with lighter stuff in the form of panels. In such a framework for a door, the vertical pieces are called stiles, and the horizontal pieces are called rails. There are always at least two stiles and at least two rails, a stile at each side of the door, and a rail at top and bottom, but there may be more than two of each of these members. The stiles usually extend the full height of the door, from top to bottom, and the rails are tenoned into them. As mentioned above, the number of rails may be varied to suit the conditions, or the taste of the designer, so that the door will have many small panels, or a few larger ones. After the frame has been built up in this way, the door may be finished as desired, that is, with sunk panels in the spaces between the rails and stiles, or with the framework covered with sheathing on one or both sides so as to present a plain surface without panels. Most of the simple, heavy doors for use in inconspicuous positions, such as doors for barns and outhouses, gates on walls, etc., are made with only one side covered with sheathing fastened to a rough frame.

The sheathing is sometimes put on vertically or horizontally, but a much stronger door is obtained if it is put on diagonally. It is possible, indeed, to make a satisfactory door by the use of sheathing alone, without any frame. The sheathing is put together in two thicknesses, and diagonally, but each thickness is made diagonal in the opposite direction to the other thickness so that all the pieces cross each other. Such a door is shown in Fig. 347. In Fig. 348 is shown a door with diagonal sheathing on the outside of a framework. Fig. 349 shows a strong type of door with a braced frame which is covered on one or both sides with vertical sheathing.

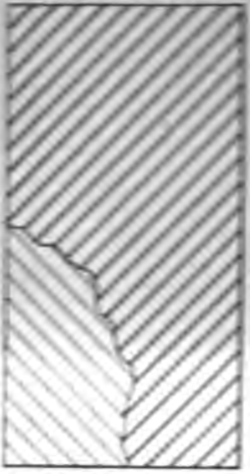


Fig. 347. Double-Diagonal Door Sheathing

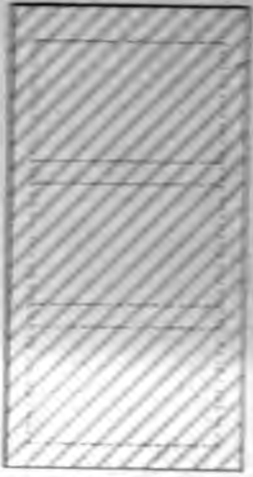


Fig. 348. Diagonal Sheathing on Door Frame

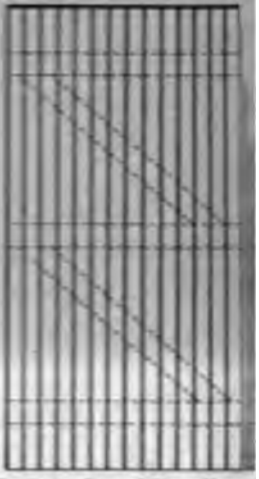


Fig. 349. Braced Door Fram with Vertical Sheathing

There is no difficulty in fastening together the simple doors just described, but when we come to the paneled doors, there are some special methods in use for fastening the rails into the stiles at the corners, which must be described. There are also special ways of building up the members of which the doors are composed, to prevent warping and twisting.

In Fig. 350 is shown the most simple type of door for use in the interior of a building. It is called a "four-panel" door on account of the arrangement of the panels and their number. The stiles, marked *A* in the figure, are all made not less than 4½ inches in width. The middle rail, marked *B*, is made 8 inches wide, and the top rail *C* the same as the stiles. The bottom rail, marked *D*, is made wider also, its width being about 10 inches. The panels are marked *EE*.

Figs. 351 and 352 show other arrangements of panels which may be employed, but the sizes are all the same as in Fig. 350. Of course, the more cross rails there are between the top rail and the bottom rail, the stronger will be the door.

The point of greatest interest in the construction of a door is the joint between the top rail *C* and the stiles *AA*. The rail is always tenoned into the stiles, the stiles continuing all the way up to the top edge of the door, and this joint is never made as a mitered joint. Fig. 353 shows the tenon by dotted lines.

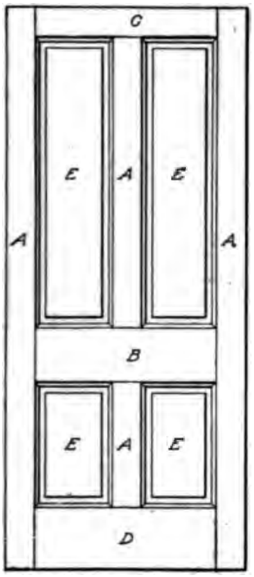


Fig. 350. Four-Panel Door

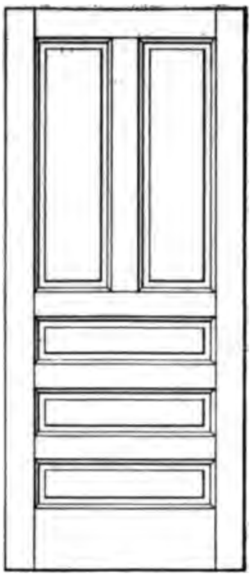


Fig. 351. Door with Horizontal Panels

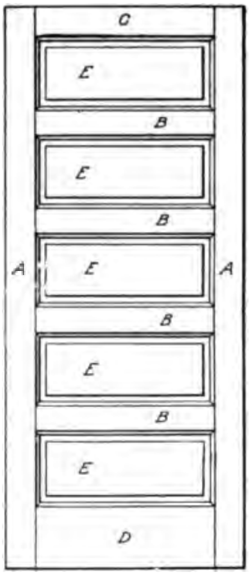


Fig. 352. Another Form of Door Paneling

It will be seen that it does not go all the way through the stile of the door but should be stopped back about ½ inch, so as not to show on the edge of the door.

Fig. 354 shows how a door should be constructed, the figure being a section taken through the stile of the door. The entire piece is built up out of strips of pine ⅞ inch thick, and of a width equal to the thickness of the door, minus ½ inch for a veneering of

$\frac{1}{4}$ inch thick on each side of the door. These strips are carefully glued together, side by side, thus forming the finished piece on which the veneering is applied. Fig. 354 also shows the proper construction of a panel at the place where it joins the stile or the rail.

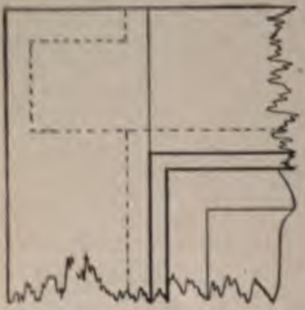


Fig. 353. Construction of Joints between Top Rail and Door Stile

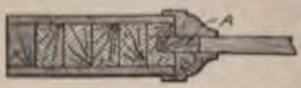


Fig. 354. Section Showing Panel Construction

A piece marked *A* in the figure is first glued into the stile or rail, and to this are glued the panel moldings, after the panel has been put in place, the panel moldings projecting out beyond the piece *A* far enough to hold the panel, which is thus left free to move as it shrinks or swells. The panel will remain as a plain surface, and will not bulge or crack. The moldings should never be fastened in any way to the panel itself. Unless the panel is absolutely free to move it is sure to crack badly.

TRIM

Base or Skirting. The walls and ceilings of rooms in which there is no attempt made to give an ornamental treatment in woodwork are ordinarily finished in plaster. Even in the cheapest work, however, there should be some sort of finish at the point where the floor and the wall meet, in order to stop the plaster and the finished flooring. This member is called the "base" or "skirting" and is almost invariably of wood. It may be of hard wood, or of soft wood for painting, and may be very plain or very ornamental. Such a base would ordinarily be made out of stuff $\frac{7}{8}$ inch or $1\frac{1}{8}$ inches thick, and would be made from 8 to 10 inches high above the floor. The top of this member is usually molded in some way. Fig. 355 shows ich a base, made very plain. It is about 8 inches high, slightly

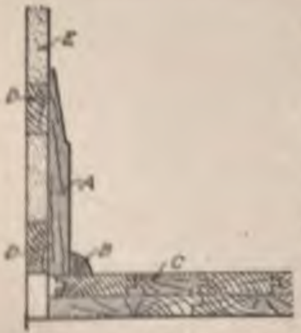


Fig. 355. Section of Base Board or Skirting

molded at the top, as shown at *A* in the figure. The finished flooring *C* passes under the base, in which case the flooring must be laid first, but the base may be set in place before the flooring is laid, and the flooring stop against it, in which case it is necessary to place a quarter-round molding, as shown at *B* in the figure, to cover the joint between the two. *E* is the plastering against which the base sets and *DD* are grounds of wood which are nailed to the studding or furring before the lathing and plastering are done, so as to provide something to which the base may be nailed. The base should not, however, be fastened at both top and bottom, as it is likely to crack if it does not have a chance to swell and move freely in one direction. The plastering may be carried down behind the place where the base is to go or not, as desired. If the plastering is carried down to the floor, a warmer building is obtained than would be the case if the plastering were to be stopped at the top of the base.

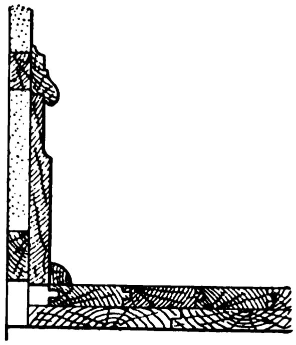


Fig. 356. Section of Two-Piece Base

Fig. 356 shows how the base may be built up out of two pieces so as to save material, the upper part being taken out of thicker stuff than the lower part. If this base were made in one piece it would be necessary to take the entire member out of the thick stuff and waste material in the lower portion. In this manner it is possible to build up the base in any shape desired, and to make it of as many pieces as seems advisable. A base may be made to any height up to 12 or 14 inches, but these heights are excessive for a base. If it is necessary to protect the wall up to a greater height than can be covered by means of a base, or if an ornamental effect is desired, a wainscot is used.

Wainscoting. Whenever it is not desirable to carry the plastering down to the floor, for any reason, it is customary to make use of a wainscot, which is a covering of woodwork about 3 or 4 feet high, which either goes on top of the plaster or takes the place of the plaster on the inside of the room. Such a covering may be made higher, up to 6 or 7 feet, and it is then known as a "dado," but the two names are very loosely used and are often confused, one with the other.

The most simple kind of wainscot is composed of matched sheathing, which may be ornamented by being beaded, or V-jointed, or center beaded. Fig. 357 shows a section through a few pieces of V-shaped sheathing to illustrate the meaning of the term "V-joint." The sheathing is tongued and grooved and the narrow strips are set up vertically and matched together, but each strip has the sharp edges cut away on one side, so as to form in the finished work a V-shaped depression as shown at *A* in the figure.

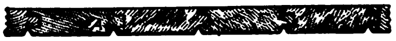


Fig. 357. V-Shaped Sheathing

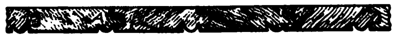


Fig. 358. Beaded Sheathing

Fig. 358 shows a section taken horizontally through a portion of some beaded sheathing. This sheathing is tongued and grooved in the sam eway as is the other sheathing described above, but instead of being V-jointed as the other is, it has a bead worked on each piece on one edge only, as shown at *A*. This makes it more expensive than the V-jointed sheathing and much more expensive than plain tongued and grooved sheathing.

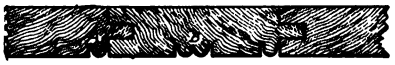


Fig. 359. Center-Beaded Sheathing

Fig. 359 shows a section through some center beaded sheathing, where, in addition to the bead *A* worked on the edge of each piece, a bead or sometimes two beads are worked in the center, as shown at *B*.

Fig. 360 shows a section taken vertically through a simple wainscot composed of matched sheathing with a base and a cap mold. The sheathing itself is shown at *B*, the plaster being at *G*, with the sheathing placed close against the plaster surface. At *C* is the base, with the top beveled to receive the sheathing. This method of receiving the sheathing on a beveled top to the base is the best, because dust and dirt will not then collect between the joints of the sheathing at the bottom, and whatever does collect there

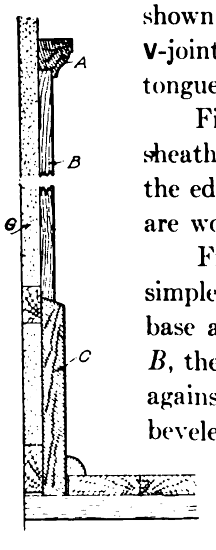


Fig. 360. Section through Simple Wainscoting

can be easily cleaned away. At *A*, is shown the cap molding which is grooved on the bottom to allow the sheathing to fit up into it. This cap mold runs the full length of the wainscot and stops

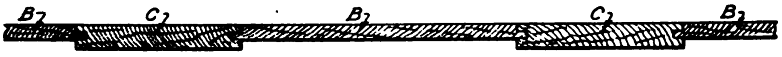


Fig. 361. Horizontal Section through Another Kind of Wainscoting

against the architraves around the windows, so that its projection can not be greater than the thickness of the architrave molding, and it should be about ⅛ inch less than this thickness.

In Fig. 361 is shown another kind of wainscoting, the section being taken horizontally through a portion of it. This form of

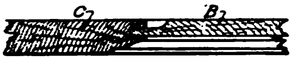


Fig. 362. Section Showing Paneled Wainscoting

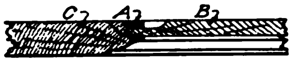


Fig. 363. Another Paneled Wainscoting

wainscoting is more expensive than simple matched or beaded sheathing, but it is not so expensive as is paneled work. It consists of pieces called "battens," as shown at *C*, with other thinner pieces grooved in between them, as shown at *B*. The battens may be ⅞ inch or 1⅛ inches in thickness, while the panels are usually made ½ inch thick. The width of the various pieces depends upon the design of the wainscoting which can be altered to suit the taste of the designer.

Fig. 362 shows the joint between the panels and the battens in simple paneled wainscoting. In this case, the battens *C* are grooved as in Fig. 361 and the panels *B* are tongued into them.

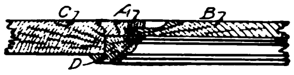


Fig. 364. Still Another Form of Wainscot Paneling

In Fig. 363 is shown a better way to fasten in the panels *B*, the piece *A* being separate from the panel and the batten, but the molding is still a part of the batten *C* itself.

Fig. 364 shows a form of paneling where both the molding *D* on the face and the piece *A* on the back are separated, and the batten *C* is cut with a rabbet to receive the molding on the face so that it will not extend too far on the face of the panel *B*, in which case it is likely to curl up a little at the edge and become separated from the panel instead of lying flat against it. This latter method is much the best, especially in the case of raised panel moldings.

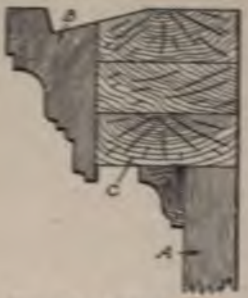


Fig. 365. Vertical Section through Plate Rail

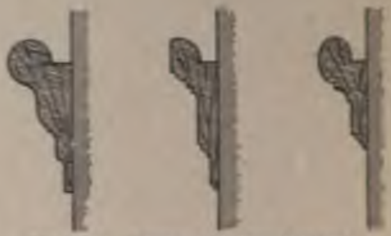


Fig. 366. Forms of Picture Molding

In dining rooms and in some other rooms it is customary to carry the wainscoting to a height of 5 or 6 feet from the floor and in this case it is usually capped with a member called a "plate rail." Fig. 365 shows a section taken vertically through such a plate rail. The wainscoting or dado *A* stops underneath the blocking *C*, and a molded piece *B* is planted onto the face of the blocking to form a finish. The projection of the rail from the wall is about 3½ inches.

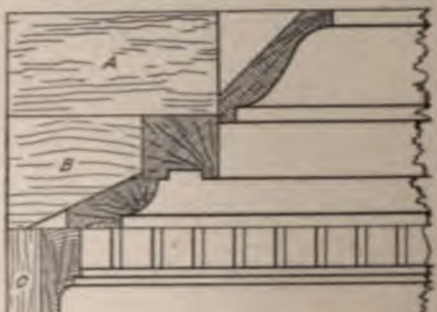


Fig. 367. Section Showing Construction of Wood Cornices

Wood Cornices. In many cases the only portion of the cornice around a room which is made of wood, is the picture molding, which is a small molding to the top of which picture hooks may be fastened. Fig. 366 shows several forms which such a molding may take.

When it is desired to have the entire cornice in wood, it should be built up out of comparatively thin pieces, say ⅞-inch stuff, and these thin pieces should be blocked out with rough blocking to the extent desired. In Fig. 367, *A*, *B*, and *C* are furring strips placed about 2 feet apart and the shaded portions represent the pieces out of which the cornice is built up.

Wood Ceiling Beams. It is often necessary or desirable to have beams showing in the ceiling of certain rooms, and these beams may be either true or false, that is, they may be either an ornamental covering for beams which really exist, or they may be entirely ornamental, enclosing nothing which forms part of the real construction of the building.

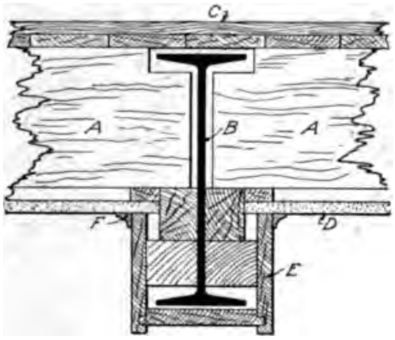
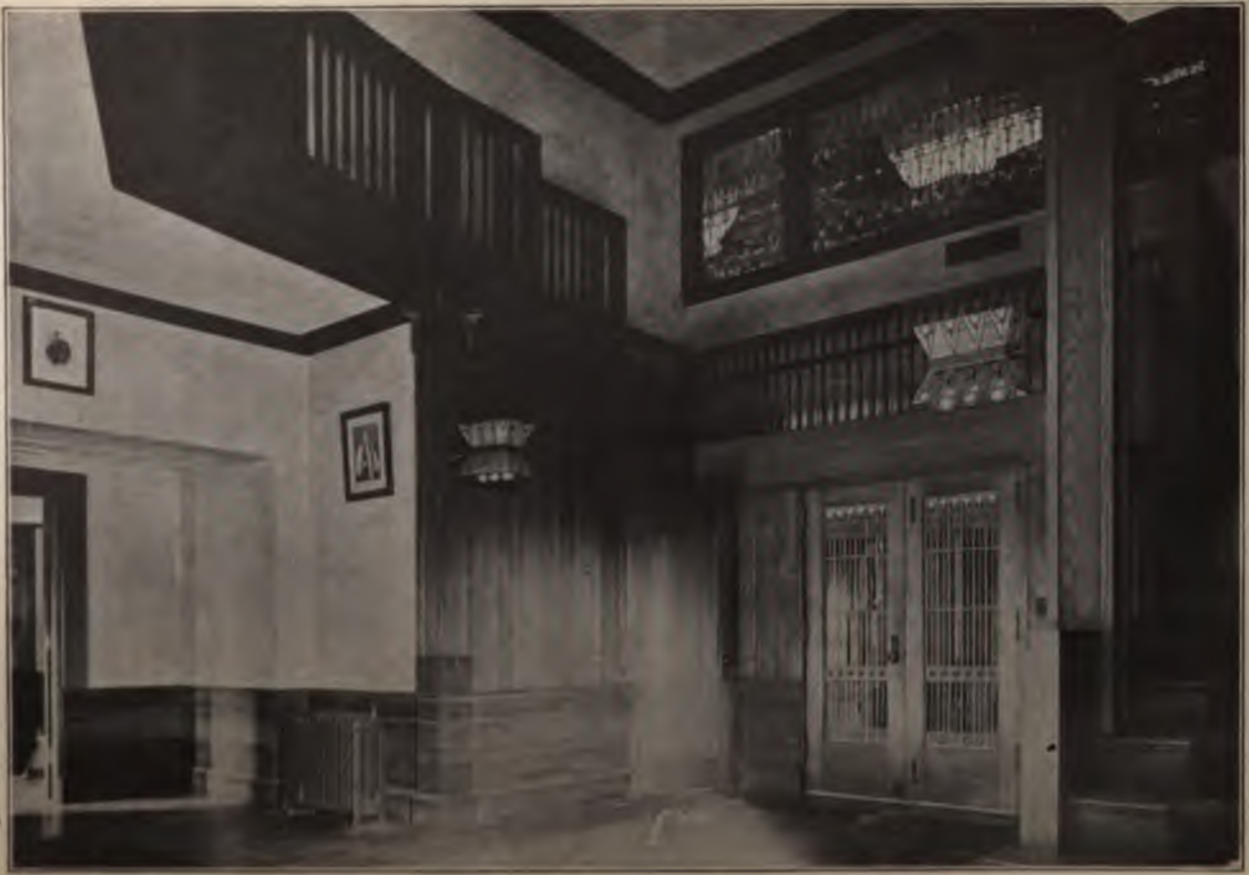


Fig. 368. Section Showing Method of Finishing Off Steel I-Beam

Fig. 368 shows how a steel beam may be covered and ornamented so as to give a finished appearance in wood in the ceiling. *AA* are the floor joists, and *B* is the steel beam. *C* is the line of the finished floor above, and *D* is the line of the finished ceiling. *E* is the finish of the ceiling beam, and *F* is a little molding to cover the joint between the plaster and the wood.

In case the beams are false, they are constructed in the same way except that the shell is filled in with blocking to take the place of the real beam shown in Fig. 368.

Staircase Finish. The subject of stair building, including the finishing of staircases, is completely covered in the article entitled "Stair Building."



ALPHA DELTA PHI CHAPTER HOUSE AT CORNELL UNIVERSITY, ITHACA, N. Y.

Dean & Dean, Architects, Chicago.

STAIR-BUILDING

Introductory. In the following instructions in the art of Stair-building, it is the intention to adhere closely to the practical phases of the subject, and to present only such matter as will directly aid the student in acquiring a practical mastery of the art.

Stair-building, though one of the most important subjects connected with the art of building, is probably the subject least understood by designers and by workmen generally. In but few of the plans that leave the offices of Architects, are the stairs properly laid down; and many of the books that have been sent out for the purpose of giving instruction in the art of building, have this common defect—that the body of the stairs is laid down imperfectly, and therefore presents great difficulties in the construction of the rail.

The stairs are an important feature of a building. On entering a house they are usually the first object to meet the eye and claim the attention. If one sees an ugly staircase, it will, in a measure, condemn the whole house, for the first impression produced will hardly afterwards be totally eradicated by commendable features that may be noted elsewhere in the building. It is extremely important, therefore, that both designer and workman shall see that staircases are properly laid out.

Stairways should be commodious to ascend—inviting people, as it were, to go up. When winders are used, they should extend past the spring line of the cylinder, so as to give proper width at the narrow end (see Fig. 72) and bring the rail there as nearly as possible to the same pitch or slant as the rail over the square steps. When the hall is of sufficient width, the stairway should not be less than four feet wide, so that two people can conveniently pass each other thereon. The height of riser and width of tread are governed by the staircase, which is the space allowed for the stairway; but, as a general rule, the tread should not be less than nine inches wide, and the riser should not be over eight inches high. Seven-inch riser and eleven-inch tread will make an easy stepping stairway. If you increase the width of the tread, you must reduce the height of the riser. The tread and riser together should not be over eighteen inches, and not less than seventeen inches. These dimensions, however, cannot always be adhered to, as conditions will often compel a deviation from the rule; for instance, in large buildings, such as hotels, railway depots, or other public buildings, treads are often made 18 inches wide, having risers of from 2½ inches to 5 inches depth.

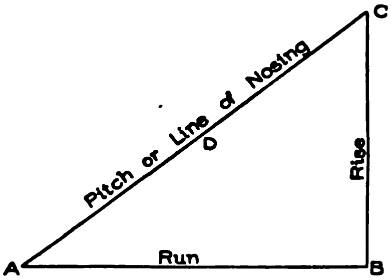


Fig. 1. Illustrating Rise, Run, and Pitch.

Definitions. Before proceeding further with the subject, it is essential that the student make himself familiar with a few of the terms used in stair-building.

The term ***rise and run*** is often used, and indicates certain dimensions of the stairway. Fig. 1 will illustrate exactly what is meant; the line A B shows the *run*, or the length over the floor the stairs will occupy. From B to C is the rise, or the total height from *top* of lower floor to *top* of upper floor.* The line D is the *pitch* or *line of nosings*, showing the angle of inclination of the stairs. On the three lines shown—the *run*, the *rise*, and the *pitch*—depends the whole system of stair-building.

The *body* or *staircase* is the room or space in which the stairway is contained. This may be a space including the width and length of the stairway only, in which case it is called a *close stairway*, no rail or baluster being necessary. Or the stairway may be in a large apartment, such as a passage or hall, or even in a large room, openings being left in the upper floors so as to allow road room for persons on the stairway, and to furnish communication between the stairways and the different stories of the building. In such cases we have what are known as *open stairways*, from the fact that they are not closed on both sides, the steps showing their ends at one side, while on the other side they are generally placed against the wall.

Sometimes stairways are left open on both sides, a practice not

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*NOTE.—The measure for the rise of a stairway must always be taken from the *top* of one floor to the *top* of the next.

uncommon in hotels, public halls, and steamships. When such stairs are employed, the openings in the upper floor should be well ***trimmed*** with joists or beams somewhat stronger than the ordinary joists used in the same floor, as will be explained further on.

Tread. This is the horizontal, upper surface of the step, upon which the foot is placed. In other words, it is the piece of material that forms the step, and is generally from 1¼ to 3 inches thick, and made of a width and length to suit the position for which it is intended. In small houses, the treads are usually made of ⅞-inch stuff.

Riser. This is the vertical height of the step. The riser is generally made of thinner stuff than the tread, and, as a rule, is not so heavy. Its duty is to connect the treads together, and to give the stairs strength and solidity.

Rise and Run. This term, as already explained, is used to indicate the horizontal and vertical dimensions of the stairway, the ***rise*** meaning the height from the top of the lower floor to the top of the second floor; and the ***run*** meaning the horizontal distance from the face of the first riser to the face of the last or top riser, or, in other words, the distance between the face of the first riser and the point where a plumb line from the face of the top riser would strike the floor. It is, in fact, simply the distance that the treads would make if put side by side and measured together—without, of course, taking in the nosings.

Suppose there are fifteen treads, each being 11 inches wide; this would make a run of 15 × 11 = 165 inches = 13 feet 9 inches. Sometimes this distance is called the *going* of the stair; this, however, is an English term, seldom used in America, and when used, refers as frequently to the length of the single tread as it does to the *run* of the stairway.

String-Board. This is the board forming the side of the stairway, connecting with, and supporting the ends of the steps. Where the steps are ***housed,*** or grooved into the board, it is known by the term ***housed string;*** and when it is cut through for the tread to rest upon, and is mitered to the riser, it is known by the term *cut and mitered* ***string.*** The dimensions of the lumber generally used for the purpose in practical work, are 9½ inches width and ⅞ inch thickness. In the first-class stairways the thickness is usually 1⅛ inches, for both front and wall strings.

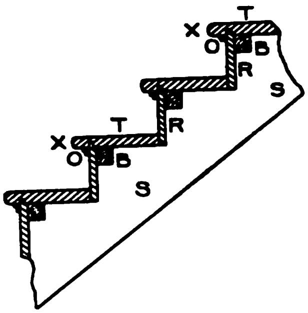


Fig. 2. Common Method of Joining Risers and Treads.

Fig. 2 shows the manner in which most stair-builders put their risers and treads together. *T* and *T* show the treads; *R* and *R*, the risers; *S* and *S*, the string; *O* and *O*, the cove mouldings under the nosings *X* and *X*. *B* and *B* show the blocks that hold the treads and risers together; these blocks should be from 4 to 6 inches long, and made of very dry wood; their section may be from 1 to 2 inches square. On a tread 3 feet long, three of these blocks should be used at about equal distances apart, putting the two outside ones about 6 inches from the strings. They are glued up tight into the angle. First warm the blocks; next coat two adjoining sides with good, strong glue; then put them in position, and nail them firmly to both tread and riser. It will be noticed that the riser has a lip on the upper edge, which enters into a groove in the tread. This lip is generally about ⅜ inch long, and may be ⅜ inch or ½ inch in thickness. Care must be taken in getting out the risers, that they shall not be made too narrow, as allowance must be made for the lip.

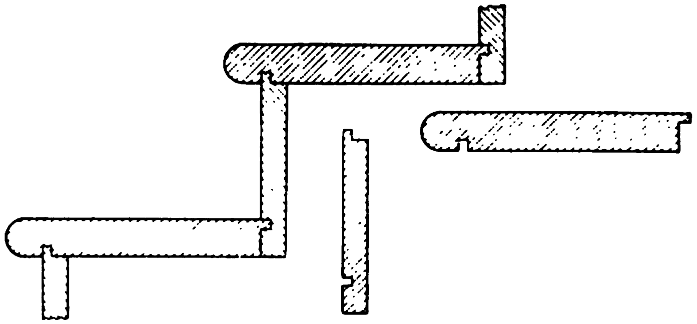
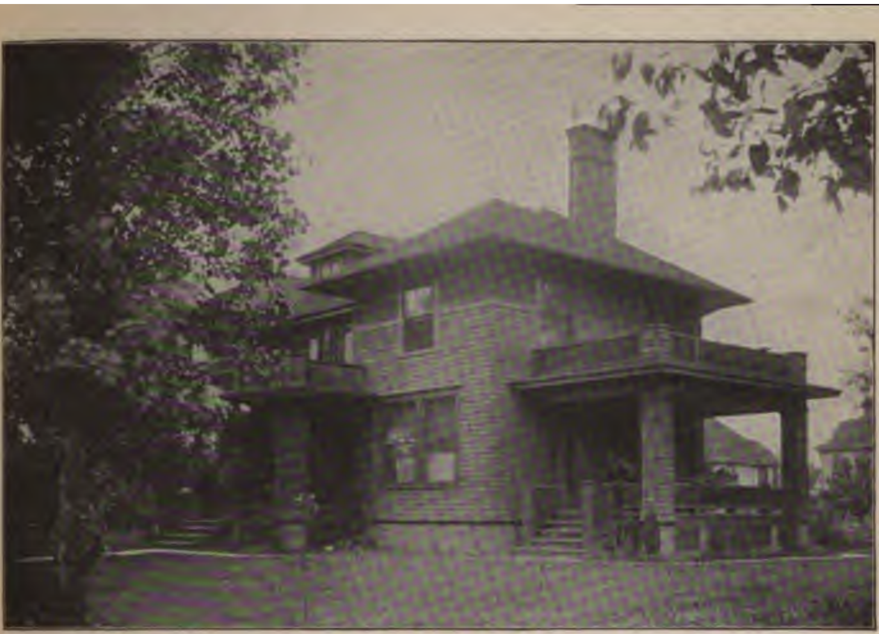


Fig. 3. Vertical Section of Stair Steps.

Fig. 4. End Section of Riser.

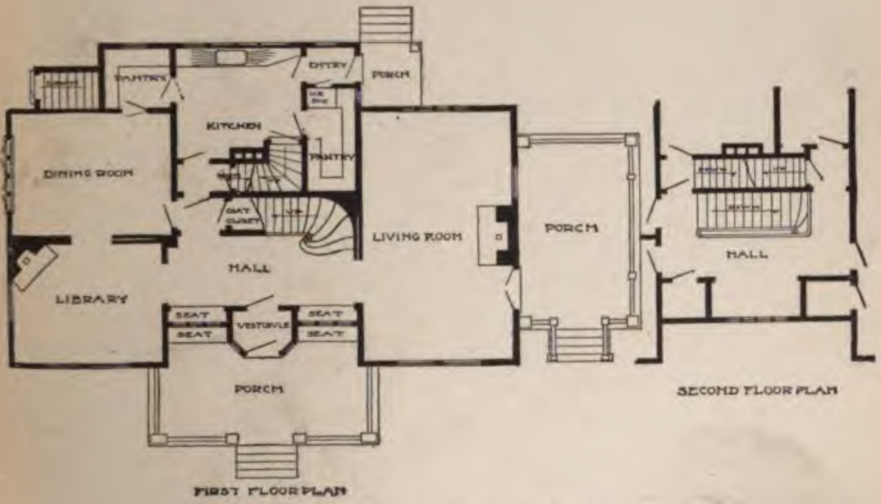
Fig. 5. End Section of Tread.

If the riser is a little too wide, this will do no harm, as the over-width may hang down below the tread; but it must be cut the exact width where it rests on the string. The treads must be made the exact width required, before they are grooved or have the nosing



HOUSE IN URBANA, ILL.

White & Temple, Architects, University of Illinois
Walls and Roof Shingled. Cost, $5,000-$5,500. View Taken from Southwest.
For Interiors, See Page 203.



FIRST FLOOR PLAN

SECOND FLOOR PLAN

PLANS OF HOUSE IN URBANA, ILL.

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LENOX AND
FOUNDATIONS

worked on the outer edge. The lip or tongue on the riser should fit snugly in the groove, and should *bottom.* By following these last instructions and seeing that the ***blocks*** are well glued in, a good solid job will be the result.

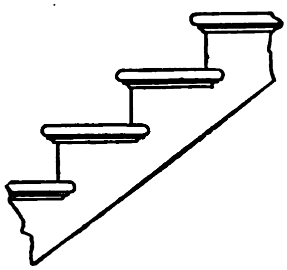

Fig. 6. Side Elevation of Finished Steps with Return Nosings and Cove Moulding.

Fig. 3 is a vertical section of stair steps in which the risers are shown tongued into the under side of the tread, as in Fig. 2, and also the tread tongued into the face of the riser. This last method is in general use throughout the country. The stair-builder, when he has steps of this kind to construct, needs to be very careful to secure the exact width for tread and riser, including the tongue on each. The usual method, in getting the parts prepared, is to make a pattern showing the end section of each. The millman, with these patterns to guide him, will be able to run the material through the machine without any danger of leaving it either too wide or too narrow; while, if he is left to himself without patterns, he is liable to make mistakes. These patterns are illustrated in Figs. 4 and 5 respectively, and, as shown, are merely end sections of riser and tread.

Fig. 6 is a side elevation of the steps as finished, with return nosings and cove moulding complete.

A front elevation of the finished step is shown in Fig. 7, the nosing and riser returning against the base of the newel post. Often the newel post projects past the riser, in front; and when such is the case, the riser and nosing are cut square against the base of the newel.

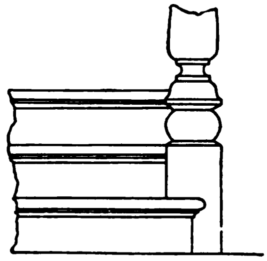

Fig. 7. Front Elevation of Finished Steps.

Fig. 8 shows a portion of a cut and mitered string, which will give an excellent idea of the method of construction. The letter *O* shows the nosing, *F* the return nosing with a bracket terminating against it. These brackets are about $\frac{5}{16}$ inch thick, and are *planted* (nailed) on the string; the brackets miter with the ends of the risers; the ends of the brackets which miter with the risers, are to be the same height as the riser. The lower ends of two balusters are shown at *G G;* and the dovetails or mortises to receive these are shown at *E E.* Generally two balusters are placed on each tread, as shown; but there are sometimes instances in which three are used, while in others only one baluster is made use of.

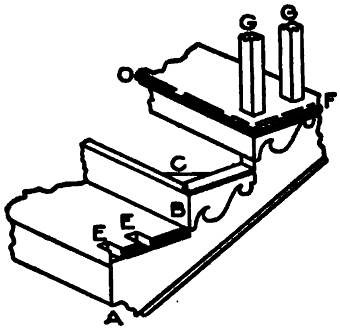

Fig. 8. Portion of a Cut and Mitered String, Showing Method of Constructing Stairs.

An end portion of a cut and mitered string is shown in Fig. 9, with part of the string taken away, showing the *carriage*—a rough piece of lumber to which the finished string is nailed or otherwise fastened. At *C* is shown the return nosing, and the manner in which the work is finished. A rough bracket is sometimes nailed on the carriage, as shown at *D,* to support the tread. The balusters are shown dovetailed into the ends of the treads, and are either glued or nailed in place, or both. On the lower edge of string, at *B,* is a return bead or moulding. It will be noticed that the rough carriage is *cut in* snugly against the floor joist.

Fig. 10 is a plan of the portion of a stairway shown in Fig. 9. Here the position of the string, bracket, riser, and tread can be seen. At the lower step is shown how to miter the riser to the string; and at the second step is shown how to miter it to the bracket.

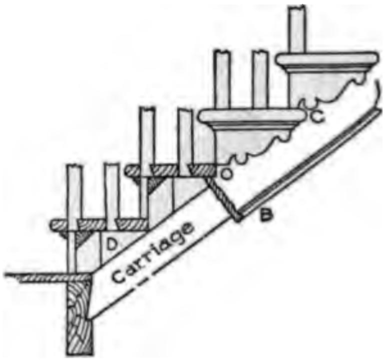

Fig. 9. End Portion of Cut and Mitered String, with Part Removed to Show Carriage.

Fig. 11 shows a quick method of marking the ends of the treads for the dovetails for balusters. The templet *A* is made of some thin material, preferably zinc or hardwood. The dovetails are outlined as shown, and the intervening portions of the material are cut away, leaving the dovetail portions solid. The templet is then nailed or screwed to a gauge-block *E,* when the whole is ready for use. The method of using is clearly indicated in the illustration.

Strings. There are two main kinds of stair strings—*wall strings* and *cut strings*. These are divided, again, under other names, as *housed* strings, *notched* strings, *staved* strings, and *rough* strings.

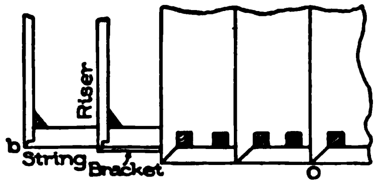

Fig. 10. Plan of Portion of Stair.

Wall strings are the supporters of the ends of the treads and risers that are against the wall; these strings may be at both ends of the treads and risers, or they may be at one end only. They may be *housed* (grooved) or left solid. When housed, the treads and risers are keyed into them, and glued and blocked. When left solid, they have a rough string or carriage spiked or screwed to them, to lend additional support to the ends of risers and treads. Stairs made after this fashion are generally of a rough, strong kind, and are especially adapted for use in factories, shops, and warehouses, where strength and rigidity are of more importance than mere external appearance.

Open strings are outside strings or supports, and are cut to the proper angles for receiving the ends of the treads and risers. It is over a string of this sort that the rail and balusters range; it is also on such a string that al nosings return; hence, in some localities, an open string is known as a *return string*.

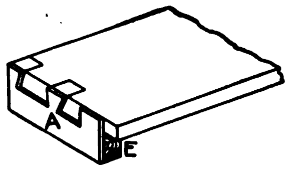

Fig. 11. Templet Used to Mark Dovetail Cuts for Balusters.

Housed strings are those that have grooves cut in them to receive the ends of treads and risers. As a general thing, wall strings are housed. The housings are made from $\frac{5}{8}$ to $\frac{3}{4}$ inch deep, and the lines at top of tread and face of riser are made to correspond with the lines of riser and tread when in position. The back lines of the housings are so located that a taper wedge may be driven in so as to force the tread and riser close to the face shoulders, thus making a tight joint.

Rough strings are cut from undressed plank, and are used for strengthening the stairs. Sometimes a combination of rough-cut strings is used for circular or geometrical stairs, and, when framed together, forms the support or carriage of the stairs.

Staved strings are built-up strings, and are composed of narrow pieces glued, nailed, or bolted together so as to form a portion of a cylinder. These are sometimes used for circular stairs, though in ordinary practice the circular part of a string is a part of the main string bent around a cylinder to give it the right curve.

Notched strings are strings that carry only treads. They are generally somewhat narrower than the treads, and are housed across their entire width. A sample of this kind of string is the side of a common step-ladder. Strings of this sort are used chiefly in cellars, or for steps intended for similar purposes.

Setting Out Stairs. In setting out stairs, the first thing to do is to ascertain the locations of the first and last risers, with the height of the story wherein the stair is to be placed. These points should be marked out, and the distance between them divided off equally, giving the number of steps or treads required. Suppose we have between these two points 15 feet, or 180 inches. If we make our treads 10 inches wide, we shall have 18 treads. It must be remembered that *the number of risers is always one more than the number of treads*, so that in the case before us there will be 19 risers.

The height of the story is next to be exactly determined, being taken on a rod. Then, assuming a height of riser suitable to the place, we ascertain, by division, how often this height of riser is contained in the height of the story; the quotient, if there is no remainder, will be the number of risers in the story. Should there be a remainder on the first division, the operation is reversed, the number of inches in the height being made the dividend, and the before-found quotient, the divisor. The resulting quotient will indicate an amount to be added to the former assumed height of riser for a new trial height. The remainder will now be less than in the former division; and if necessary, the operation of reduction by division is repeated, until the height of the riser is obtained to the thirty-second part of an inch. These heights are then set off on the story rod as exactly as possible.

The *story rod* is simply a dressed or planed pole, cut to a length exactly corresponding to the height from the top of the lower floor to the top of the next floor. Let us suppose this height to be 11 feet 1 inch, or 133 inches. Now, we have 19 risers to place in this space, to enable us to get upstairs; therefore, if we divide 133 by 19, we get 7 without any remainder. Seven inches will therefore be the width or height of the riser. Without figuring this out, the workman may find the exact width of the riser by dividing his story rod, by means of pointers, into 19 equal parts, any one part being the proper width. It may be well, at this point, to remember that *the first riser must always be narrower than the others,* because the thickness of the first tread must be taken off.

The width of treads may also be found without figuring, by pointing off the *run* of the stairs into the required number of parts; though, where the student is qualified, it is always better to obtain the width, both of treads and of risers, by the simple arithmetical rules.

Having determined the width of treads and risers, a *pitch-board* should be formed, showing the angle of inclination. This is done by cutting a piece of thin board or metal in the shape of a right-angled triangle, with its base exactly equal to the run of the step, and its perpendicular equal to the height of the riser. It is a general maxim, that the greater the breadth of a step or tread, the less should be the height of the riser; and, conversely, the less the breadth of a step, the greater should be the height of the riser. The proper relative dimensions of treads and risers may be illustrated graphically, as in Fig. 12.

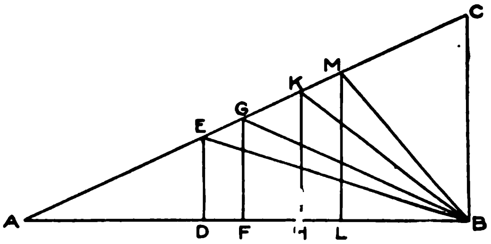

Fig. 12. Graphic Illustration of Proportional Dimensions of Treads and Risers.

In the right-angle triangle $A\ B\ C$, make $A\ B$ equal to 24 inches, and $B\ C$ equal to 11 inches—the standard proportion. Now, to find the riser corresponding to a given width of tread, from B, set off on $A\ B$ the width of the tread, as $B\ D$; and from D, erect a perpendicular $D\ E$, meeting the hypotenuse in E; then $D\ E$ is the height of the riser; and if we join B and E, the angle $D\ B\ E$ is the angle of inclination, showing the slope of the ascent. In like manner, where $B\ F$ is the width of the tread, $F\ G$ is the riser, and $B\ G$ the slope of the stair. A width of tread $B\ H$ gives a riser of the height of $H\ K$; and a width of tread equal to $B\ L$ gives a riser equal to $L\ M$

In the opinion of many builders, however, a better scheme of proportions for treads and risers is obtained by the following method:

Set down two sets of numbers, each in arithmetical progression—the first set showing widths of tread, increasing by inches; the other showing heights of riser, decreasing by half-inches.

Treads, Inches	Risers, Inches
5	9
6	8½
7	8
8	7½
9	7
10	6½
11	6
12	5½
13	5
14	4½
15	4
16	3½
17	3
18	2½

It will readily be seen that each pair of treads and risers thus obtained is suitably proportioned as to dimensions.

It is seldom, however, that the proportions of treads and risers are entirely a matter of choice. The space allotted to the stairs usually determines this proportion; but the above will be found a useful standard, to which it is desirable to approximate.

In the better class of buildings, the number of steps is considered in the plan, which it is the business of the Architect to arrange; and in such cases, the height of the story rod is simply divided into the number required.

Pitch-Board. It will now be in order to describe a pitch-board and the manner of using it; no stairs can be properly built without the use of a pitch-board in some form or other. Properly speaking, a pitch-board, as already explained, is a thin piece of material, generally pine or sheet metal, and is a right-angled triangle in outline. One of its sides is made the exact height of the rise; at right angles with this line of rise, the exact width of the tread is measured off; and the material is cut along the hypotenuse of the right-angled triangle thus formed.

The simplest method of making a pitch-board is by using a steel square, which, of course, every carpenter in this country is supposed to possess. By means of this invaluable tool, also, a stair string can be laid out, the square being applied to the string as shown in Fig. 13. In the instance here illustrated, the square shows 10 inches for the tread and 7 inches for the rise.

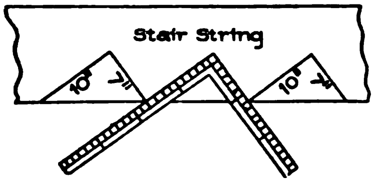

Fig. 13. Steel Square Used as a Pitch-Board in Laying Out Stair String.

To cut a pitch-board, after the tread and rise have been determined, proceed as follows: Take a piece of thin, clear material, and lay the square on the face edge, as shown in Fig. 13. Mark out the pitch-board with a sharp knife; then cut out with a fine saw, and dress to the knife marks; nail a piece on the largest edge of the pitch-board for a gauge or fence, and it is ready for use.

Fig. 14 shows the pitch-board pure and simple; it may be half an inch thick, or, if of hardwood, may be from a quarter-inch to a half-inch thick.

Fig. 15 shows the pitch-board after the gauge or fence is nailed on. This fence or gauge may be about 1½ inches wide and from ⅜ to ¾ inch thick.

Fig. 16 shows a sectional view of the pitch-board with a fence nailed on.

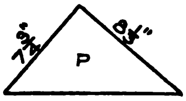

Fig. 14.

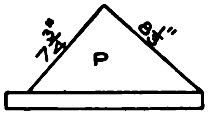

Fig. 15.

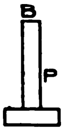

Fig. 16.

Showing How a Pitch-Board is Made.
Fig. 15 shows gange fastened to long edge; Fig. 16 is a sectional elevation of completed board.

In Fig. 17 the manner of applying the pitch-board is shown. *R R R* is the string, and the line *A* shows the jointed or straight edge of the string. The pitch-board *P* is shown in position, the line 8⅓ represents the step or tread, and the line 7¾ shows the line of the riser. These two lines are of course at right angles, or, as the carpenter would say, they are *square*. This string shows four complete cuts, and part of a fifth cut for treads, and five complete cuts for risers. The bottom of the string at *W* is cut off at the line of the floor on which it is supposed to rest. The line *C* is the line of the first riser. This riser is cut lower than any of the other risers, because, as above explained, the thickness of the first tread is always taken off it; thus, if the tread is 1½ inches thick, the riser in this case would only require to be 6¼ inches wide, as 7¾ − 1½ = 6¼.

The string must be cut so that the line at *W* will be only 6¼ inches from the line at 8½, and these two lines must be parallel. The first riser and tread having been satisfactorily dealt with, the rest can easily be marked off by simply sliding the pitch-board along the line *A* until the outer end of the line 8½ on the pitch-board strikes the outer end of the line 7¾ on the string, when another tread and another riser are to be marked off. The remaining risers and treads are marked off in the same manner.

Sometimes there may be a little difficulty at the top of the stairs, in fitting the string to the trimmer or joists; but, as it is necessary first to become expert with the pitch-board, the method of trimming the well or attaching the cylinder to the string will be left until other matters have been discussed.

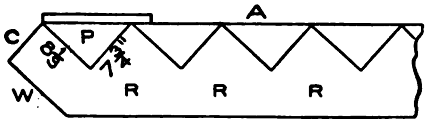

Fig. 17. Showing Method of Using Pitch-Board.

Fig. 18 shows a portion of the stairs in position. *S* and *S* show the strings, which in this case are cut square; that is, the part of the string to which the riser is joined is cut square across, and the butt or end wood of the riser is seen. In this case, also, the end of the tread is cut square off, and flush with the string and riser. Both strings in this instance are open strings. Usually, in stairs of this kind, the ends of the treads are rounded off similarly to the front of the tread, and the ends project over the strings the same distance that the front edge projects over the riser. If a moulding or *cove* is used under the nosing in front, it should be carried round on the string to the back edge of the tread and cut off square, for in this case the back edge of the tread will be square. A riser is shown at *R*, and it will be noticed that it runs down behind the tread on the back edge, and is either nailed or screwed to the tread. This is the American practice, though in England the riser usually rests on the tread, which extends clear back to string as shown at the top tread in the diagram. It is much better, however, for general purposes, that the riser go behind the tread, as this tends to make the whole stairway much stronger.

Housed strings are those which carry the treads and risers without their ends being seen. In an open stair, the wall string only is housed, the other ends of the treads and risers resting on a cut string, and the nosings and mouldings being returned as before described.

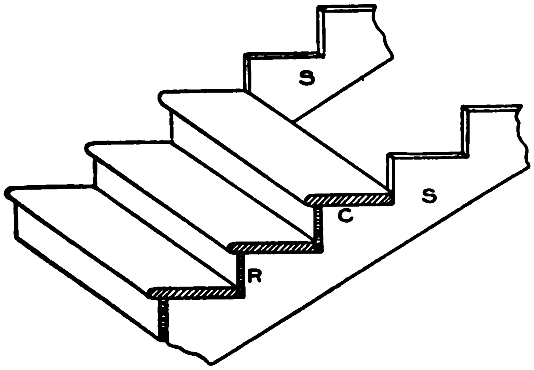

Fig. 18. Portion of Stair in Position.

The manner of housing is shown in Fig. 19, in which the treads *T T* and the risers *R R* are shown in position, secured in place respectively by means of wedges *X X* and *F F*, which should be well covered with good glue before insertion in the groove. The housings are generally made from ½ to ⅝ inch deep, space for the wedge being cut to suit.

In some closed stairs in which there is a housed string between the newels, the string is double-tenoned into the shanks of both newels, as shown in Fig. 20. The string in this example is made 12¾ inches wide, which is a very good width for a string of this kind; but the thickness should never be less than 1½ inches. The upper newel is made about 5 feet 4 inches long from drop to top of cap. These strings are generally capped with a subrail of some kind, on which the baluster, if any, is cut-mitered in. Generally a groove, the width of the square of the balusters, is worked on the top of the subrail, and the balusters are worked out to fit into this groove; then pieces of this material, made the width of the groove and a little thicker than the groove is deep, are cut so as to fit in snugly between the ends of the balusters resting in the groove. This makes a solid job; and the pieces between the balusters may be made

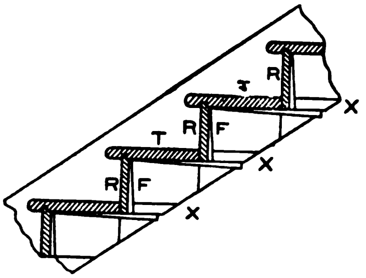

Fig. 19. Showing Method of Housing Treads and Risers.

of any shape on top, either beveled, rounded, or moulded, in which case much is added to the appearance of the stairs.

Fig. 21 exhibits the method of attaching the rail and string to the bottom newel. The dotted lines indicate the form of the tenons cut to fit the mortises made in the newel to receive them.

Fig. 22 shows how the string fits against the newel at the top; also the trimmer *E*, to which the newel post is fastened. The string in this case is tenoned into the upper newel post the same way as into the lower one.

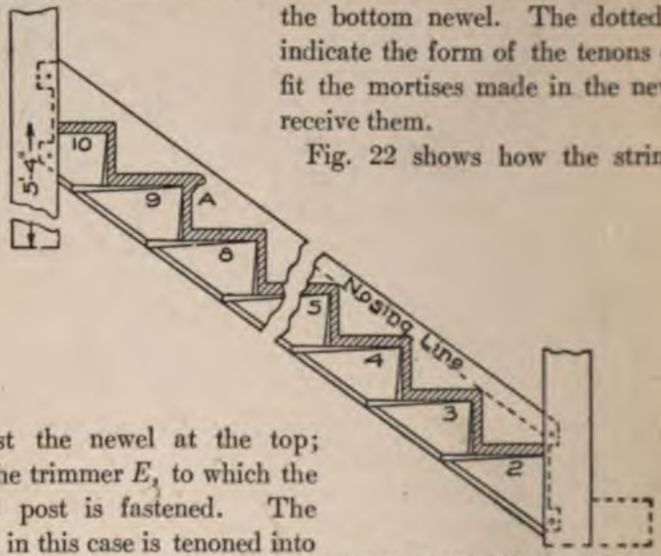

Fig. 20. Showing Method of Connecting Housed String to Newels.

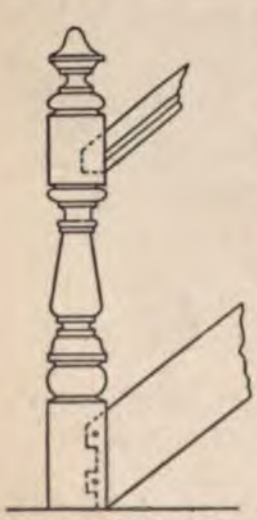

Fig. 21. Method of Connecting Rail and String to Bottom Newel.

The open string shown in Fig. 23 is a portion of a finished string, showing nosings and cove returned and finishing against the face of the string. Along the lower edge of the string is shown a bead or moulding, where the plaster is finished.

A portion of a stair of the better class is shown in Fig. 24. This is an open, bracketed string, with returned nosings and coves and scroll brackets. These brackets are made about ⅜ inch thick, and may be in any desirable pattern. The end next the riser should be mitered to suit; this will require the riser to be ⅜ inch longer than the face of the string. The upper part of the bracket should run under the cove moulding; and the tread should project over the string the full ⅜ inch, so as to cover the bracket and make the face even for the nosing and the cove moulding to fit snugly against the end of the tread and the face of the bracket. Great care must be taken about this point, or endless trouble will follow. In a bracketed stair of this kind, care must be taken in placing the newel posts, and provision must be made for the extra ⅜ inch due to the bracket. The newel post must be set out from the string ⅜ inch, and it will then align with the baluster.

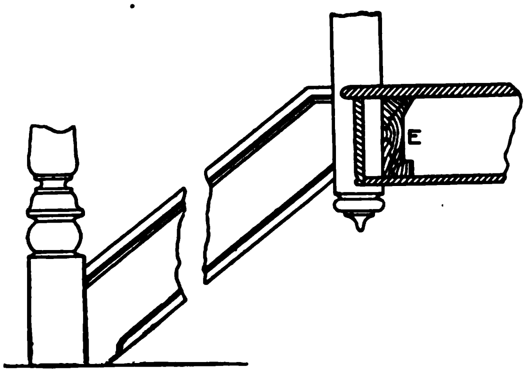

Fig. 22. Connections of String and Trimmer at Upper Newel Post.

We have now described several methods of dealing with strings; but there are still a few other points connected with these members, both housed and open, that it will be necessary to explain, before the young workman can proceed to build a fair flight of stairs. The connection of the wall string to the lower and upper floors, and the manner of affixing the outer or cut string to the upper joist and to the newel, are matters that must not be overlooked. It is the intention to show how these things are accomplished, and how the stairs are made strong by the addition of rough strings or bearing carriages.

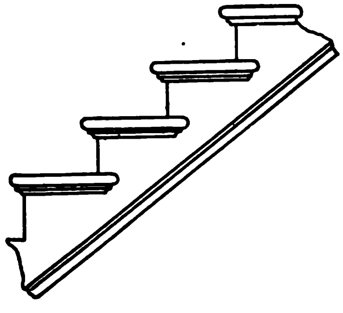

Fig. 23. Portion of Finished String, Showing Returned Nosings and Coves, also Bead Moulding.

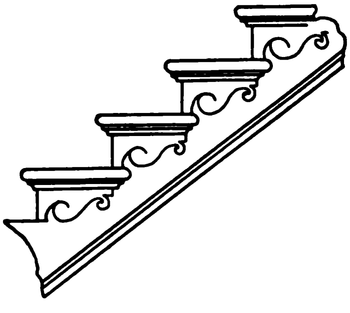

Fig. 24. Portion of Open, Bracketed String Stair, with Returned Nosings and Coves, Scroll Brackets, and Bead Moulding.

Fig. 25 gives a side view of part of a stair of the better class, with one open, cut and mitered string. In Fig. 26, a plan of this same stairway, *W S* shows the wall string; *R S*, the rough string, placed there to give the structure strength; and *O S*, the outer or cut and mitered string. At *A A* the ends of the risers are shown, and it will be noticed that they are mitered against a vertical or riser line of the string, thus preventing the end of the riser from being seen. The other end of the riser is in the housing in the wall string. The outer end of the tread is also mitered at the nosing, and a piece of material made or worked like the nosing is mitered against or returned at the end of the tread. The end of this returned piece is again returned on itself back to the string, as shown at *N* in Fig. 25. The moulding, which is ⅝-inch cove in this case, is also returned on itself back to the string.

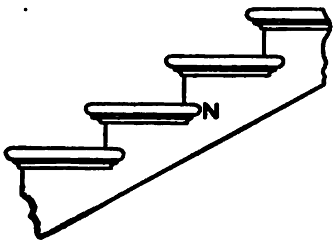

Fig. 25. Side Elevation of Part of Stair with Open, Cut and Mitered String.

The mortises shown at *B B B B* (Fig. 26), are for the balusters. It is always the proper thing to saw the ends of the treads ready for the balusters before the treads are attached to the string; then, when the time arrives to put up the rail, the back ends of the mortises can be cut out, when the treads will be ready to receive the balusters. The mortises are dovetailed, and, of course, the tenons on the balusters must be made to suit. The treads are finished on the bench; and the return nosings are fitted to them and tacked on, so that they may be taken off to insert the balusters when the rail is being put in position.

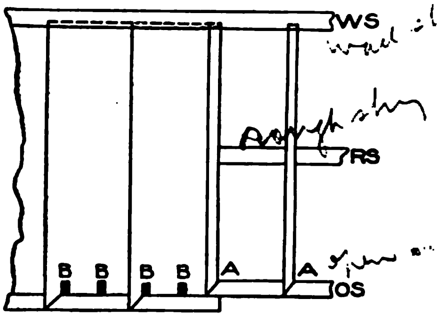

Fig. 26. Plan of Part of Stair Shown in Fig. 25.

Fig. 27 shows the manner in which a wall string is finished at the foot of the stairs. *S* shows the string, with moulding wrought on the upper edge. This moulding may be a simple ogee, or may consist of a number of members; or it may be only a bead; or, again, the edge of the string may be left quite plain; this will be regulated in great measure by the style of finish in the hall or other part of the house in which the stairs are placed. *B* shows a portion of a baseboard, the top edge of which has the same finish as the top edge of the string. *B* and *A* together show the junction of the string and base. *F F* show blocks glued in the angles of the steps to make them firm and solid.

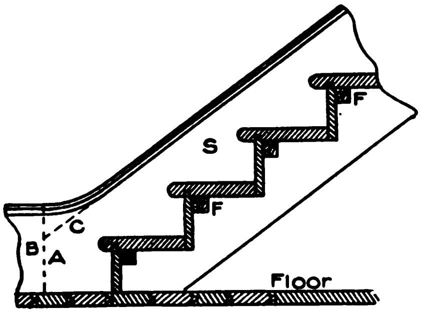

Fig. 27. Showing How Wall String Is Finished at Foot of Stair.

Fig. 28 shows the manner in which the wall string *S* is finished at the top of the stairs. It will be noticed that the moulding is worked round the ease-off at *A* to suit the width of the base at *B*. The string is cut to fit the floor and to butt against the joist. The plaster line under the stairs and on the ceiling, is also shown.

Fig. 29 shows a cut or open string at the foot of a stairway, and the manner of dealing with it at its junction with the newel post *K*. The point of the string should be mortised into the newel 2 inches, 3 inches, or 4 inches, as shown by the dotted lines; and the mortise in the newel should be cut near the center, so that the center of the baluster will be directly opposite the central line of the newel post. The proper way to manage this, is to mark the central line of the baluster on the tread, and then make this line correspond with the central line of the newel post. By careful attention to this point, much trouble will be avoided where a turned cap is used to receive the lower part of the rail.

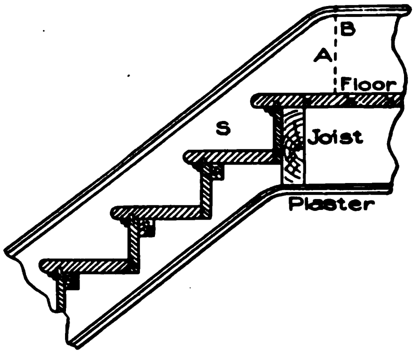

Fig. 28. Showing How Wall String Is Finished at Top of Stair.

The lower riser in a stair of this kind will be somewhat shorter than the ones above it, as it must be cut to fit between the newel and the wall string. A portion of the tread, as well as of the riser, will also butt against the newel, as shown at *W*.

If there is no spandrel or wall under the open string, it may run down to the floor as shown by the dotted line at *O*. The piece *O* is glued to the string, and the moulding is worked on the curve. If there is a wall under the string *S*, then the base *B*, shown by the dotted lines, will finish against the string, and it should have a moulding on its upper edge, the same as that on the lower edge of the string, if any, this moulding being mitered into the one on the string. When there is a base, the piece *O* is of course dispensed with.

The square of the newel should run down by the side of a joist as shown, and should be firmly secured to the joist either by spiking or by some other suitable device. If the joist runs the other way, try to get the newel post against it, if possible, either by furring out the joist or by cutting a portion off the thickness of the newel. The solidity of a stair and the firmness of the rail, depend very much upon the rigidity of the newel post. The above suggestions are applicable where great strength is required, as in public buildings. In ordinary work, the usual method is to let the newel rest on the floor.

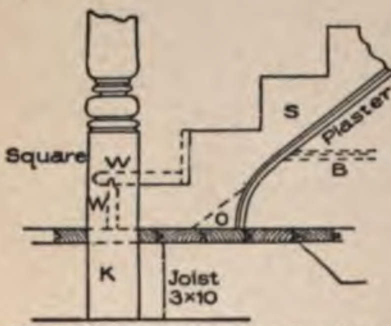

Fig. 29. Showing How a Cut or Open String is Finished at Foot of Stair.

Fig. 30 shows how the cut string is finished at the top of the stairs. This illustration requires no explanation after the instructions already given.

Thus far, stairs having a newel only at the bottom have been dealt with. There are, however, many modifications of straight and return stairs which have from two to four or six newels. In such cases, the methods of treating strings at their finishing points must necessarily be somewhat different from those described; but the general principles, as shown and explained, will still hold good.

Well-Hole. Before proceeding to describe and illustrate neweled stairs, it will be proper to say something about the *well-hole*, or the opening through the floors, through which the traveler on the stairs ascends or descends from one floor to another.

Fig. 31 shows a well-hole, and the manner of trimming it. In this instance the stairs are placed against the wall; but this is not necessary in all cases, as the well-hole may be placed in any part of the building.

The arrangement of the trimming varies according as the joists are at right angles to, or are parallel to, the wall against which the stairs are built. In the former case (Fig. 31, *A*) the joists are cut short and tusk-tenoned into the heavy trimmer *T T*, as shown in the cut. This trimmer is again tusk-tenoned into two heavy joists *T J* and *T J*, which form the ends of the well-hole. These heavy joists are called *trimming joists;* and, as they have to carry a much heavier load than other joists on the same floor, they are made much heavier. Sometimes two or three joists are placed together, side by side, being bolted or spiked together to give them the desired unity and strength. In constructions requiring great strength, the tail and header joists of a well-hole are suspended on iron brackets.

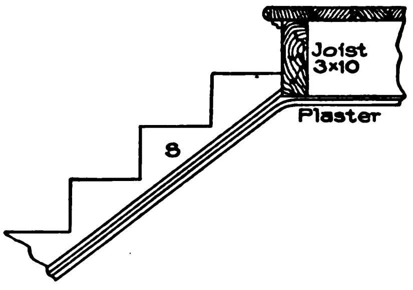

Fig. 30. Showing How a Cut or Open String is Finished at Top of Stair.

If the opening runs parallel with the joists (Fig. 31, *B*), the timber forming the side of the well-hole should be left a little heavier than the other joists, as it will have to carry short trimmers (*T J* and *T J*) and the joists running into them. The method here shown is more particularly adapted to brick buildings, but there is no reason why the same system may not be applied to frame buildings.

Usually in cheap, frame buildings, the trimmers *T T* are spiked against the ends of the joists, and the ends of the trimmers are supported by being spiked to the trimming joists *T J*, *T J*. This is not very workmanlike or very secure, and should not be done, as it is not nearly so strong or durable as the old method of framing the joists and trimmers together.

Fig. 32 shows a stair with three newels and a platform. In this example, the first tread (No. 1) stands forward of the newel post two-thirds of its width. This is not necessary in every case, but it is sometimes done to suit conditions in the hallway. The second newel is placed at the twelfth riser, and supports the upper end of the first cut string and the lower end of the second cut string. The platform (12) is supported by joists which are framed into the wall and are fastened against a trimmer running from the wall to the newel along the line 12. This is the case only when the second newel runs down to the floor.

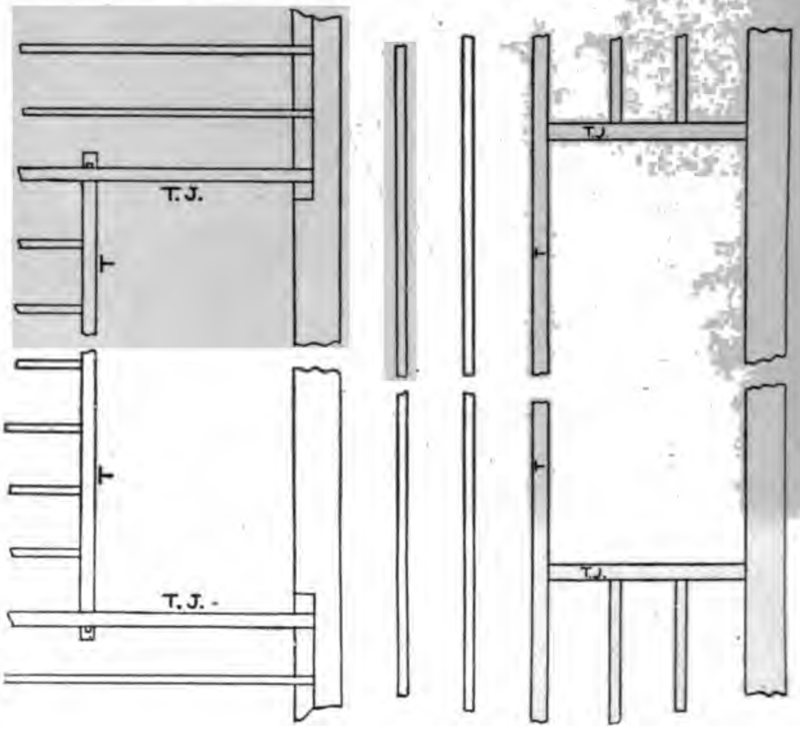

Fig. 31. Showing Ways of Trimming Well-Hole when Joists Run in Different Directions.

If the second newel does not run to the floor, the framework supporting the platform will need to be built on studding. The third newel stands at the top of the stairs, and is fastened to the joists of the second floor, or to the trimmer, somewhat after the manner of fastening shown in Fig. 29. In this example, the stairs have 16 risers

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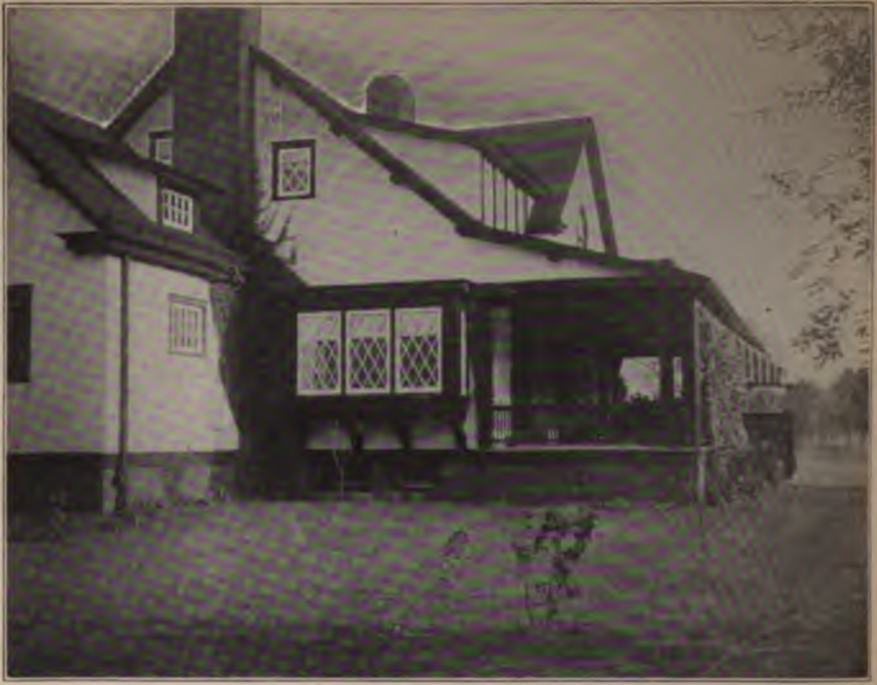
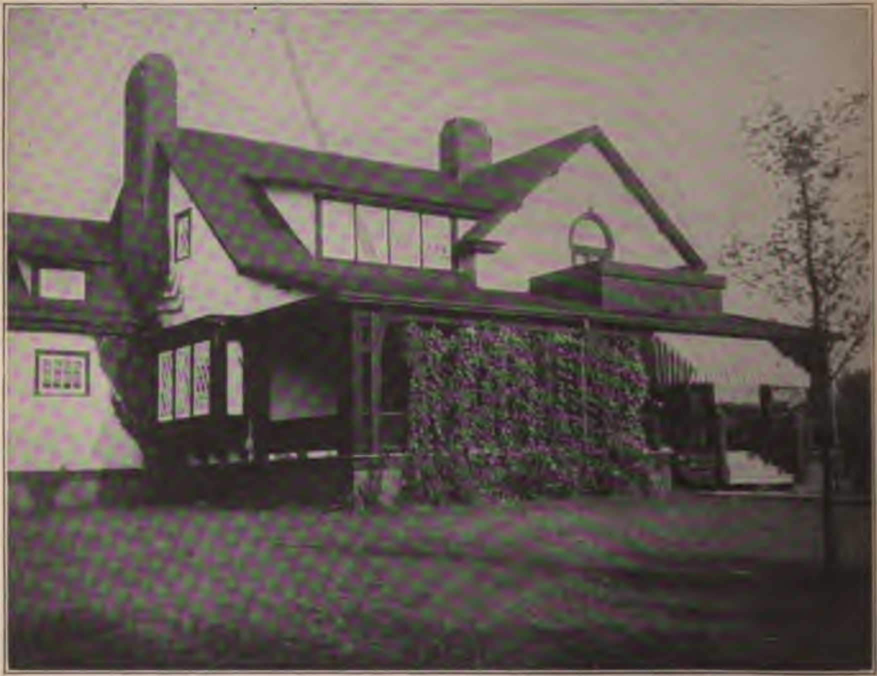
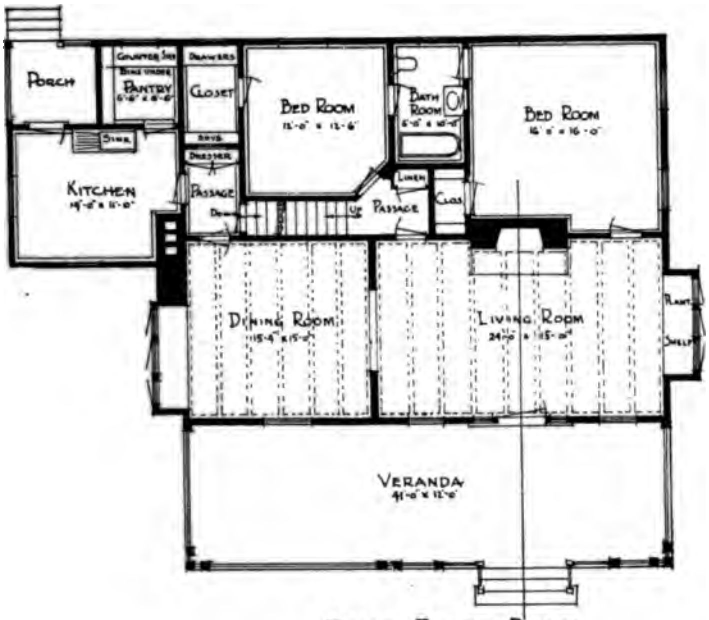




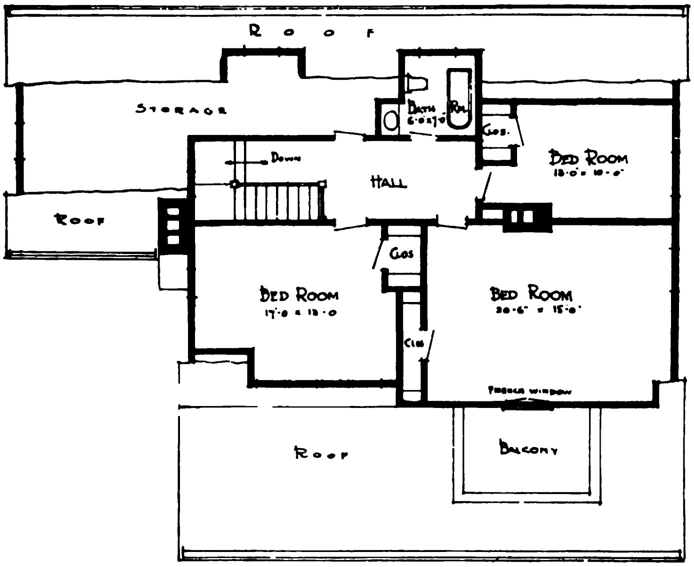
HOUSE AT WASHINGTON, ILL.

Herbert Edmund Hewitt, Architect, Peoria, Ill.

Walls of Cement on Metal Lath. Roofs Covered with Shingles Stained Green. All Outside Woodwork Stained Dark Brown. No Paint on Outside except on Sash.



FIRST FLOOR PLAN



SECOND FLOOR PLAN

HOUSE AT WASHINGTON, ILL.

Herbert Edmund Hewitt, Architect, Peoria, Ill.

Built in 1904. Cost, about $4,500. House was Built for a Summer House, but Constructed the Same as if for All Year-Round Use, and Provided with Heating Plant.

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ASTOR, LENOX AND
TILDEN FOUNDATIONS.

and 15 treads, the platform or landing (12) making one tread. The figure 16 shows the floor in the second story.

This style of stair will require a well-hole in shape about as shown in the plan; and where strength is required, the newel at the top should run from floor to floor, and act as a support to the joists and trimmers on which the second floor is laid.

Perhaps the best way for a beginner to go about building a stairway of this type, will be to lay out the work on the lower floor in the exact place where the stairs are to be erected, making everything full size. There will be no difficulty in doing this; and if the positions of the first riser and the three newel posts are accurately defined, the building of the stairs will be an easy matter. Plumb lines can be raised from the lines on the floor, and the positions of the platform and each riser thus easily determined. Not only is it best to line out on the floor all stairs having more than one newel; but in constructing any kind of stair it will perhaps be safest for a beginner to lay out in exact position on the floor the points over which the treads and risers will stand. By adopting this rule, and seeing that the strings, risers, and treads correspond exactly with the lines on the floor, many cases of annoyance will be avoided. Many expert stair-builders, in fact, adopt this method in their practice, laying out all stairs on the floor, including even the carriage strings, and they cut out all the material from the lines obtained on the floor. By following this method, one can see exactly the requirements in each particular case, and can rectify any error without destroying valuable material.

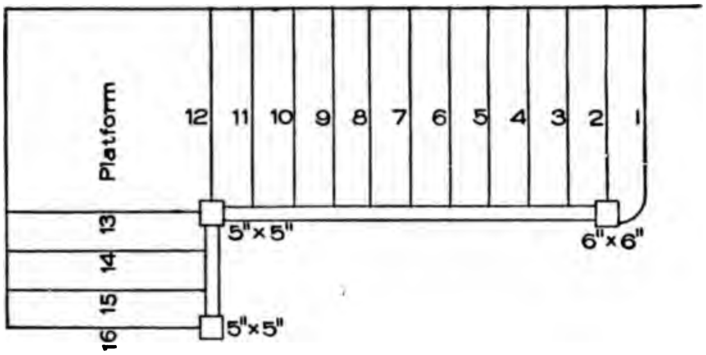


Fig. 32. Stair with Three Newels and a Platform.

Laying Out. In order to afford the student a clear idea of what is meant by *laying out* on the floor, an example of a simple close-string stair is given. In Fig. 33, the letter *F* shows the floor line; *L* is the landing or platform; and *W* is the wall line. The stair is to be 4 feet wide over strings; the landing, 4 feet wide; the height from floor to landing, 7 feet; and the run from start to finish of the stair, 8 feet 8½ inches.

The first thing to determine is the dimensions of the treads and risers. The wider the tread, the lower must be the riser, as stated before. No definite dimensions for treads and risers can be given, as the steps have to be arranged to meet the various difficulties that may occur in the working out of the construction; but a common rule is this: Make the width of the tread, plus twice the rise, equal to 24 inches. This will give, for an 8-inch tread, an 8-inch rise; for a 9-inch tread, a 7½-inch rise; for a 10-inch tread, a 7-inch rise, and so on. Having the height (7 feet) and the run of the flight (8 feet 8½ inches), take a rod about one inch square, and mark on it the height from floor to landing (7 feet), and the length of the going or run of the flight (8 feet 8½ inches). Consider now what are the dimensions which can be given to the treads and risers, remembering that there will be one more riser than the number of treads. Mark off on the rod the landing, forming the last tread. If twelve risers are desired, divide the height (namely, 7 feet) by 12, which gives 7 inches as the rise of each step. Then divide the run (namely, 8 feet 8½ inches) by 11, and the width of the tread is found to be 9½ inches.

Great care must be taken in making the pitch-board for marking off the treads and risers on the string. The pitch-board may be made from dry hardwood about ⅜ inch thick. One end and one side must be perfectly square to each other; on the one, the width of the tread is set off, and on the other the height of the riser. Connect the two points thus obtained, and saw the wood on this line. The addition of a gauge-piece along the longest side of the triangular piece, completes the pitch-board, as was illustrated in Fig. 15.

The length of the wall and outer string can be ascertained by means of the pitch-board. One side and one edge of the wall string must be squared; but the outer string must be trued all round. On the strings, mark the positions of the treads and risers by using the pitch-board as already explained (Fig. 17). Strings are usually made 11 inches wide, but may be made 12½ inches wide if necessary for strength.

After the widths of risers and treads have been determined, and the string is ready to lay out, apply the pitch-board, marking the first riser about 9 inches from the end; and number each step in succession. The thickness of the treads and risers can be drawn by using thin strips of hardwood made the width of the housing required. Now allow for the wedges under the treads and behind the risers, and thus find the exact width of the housing, which should be about ⅝ inch

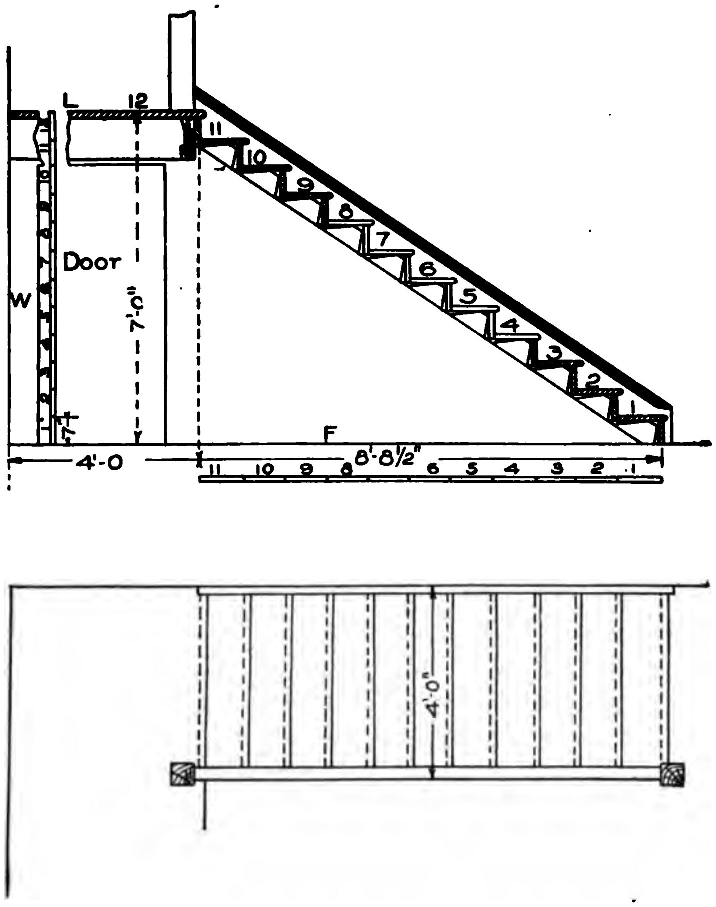


Fig. 33. Method of Laying Out a Simple, Close-String Stair.

deep; the treads and risers will require to be made 1¼ inches longer than shown in the plan, to allow for the housings at both ends.

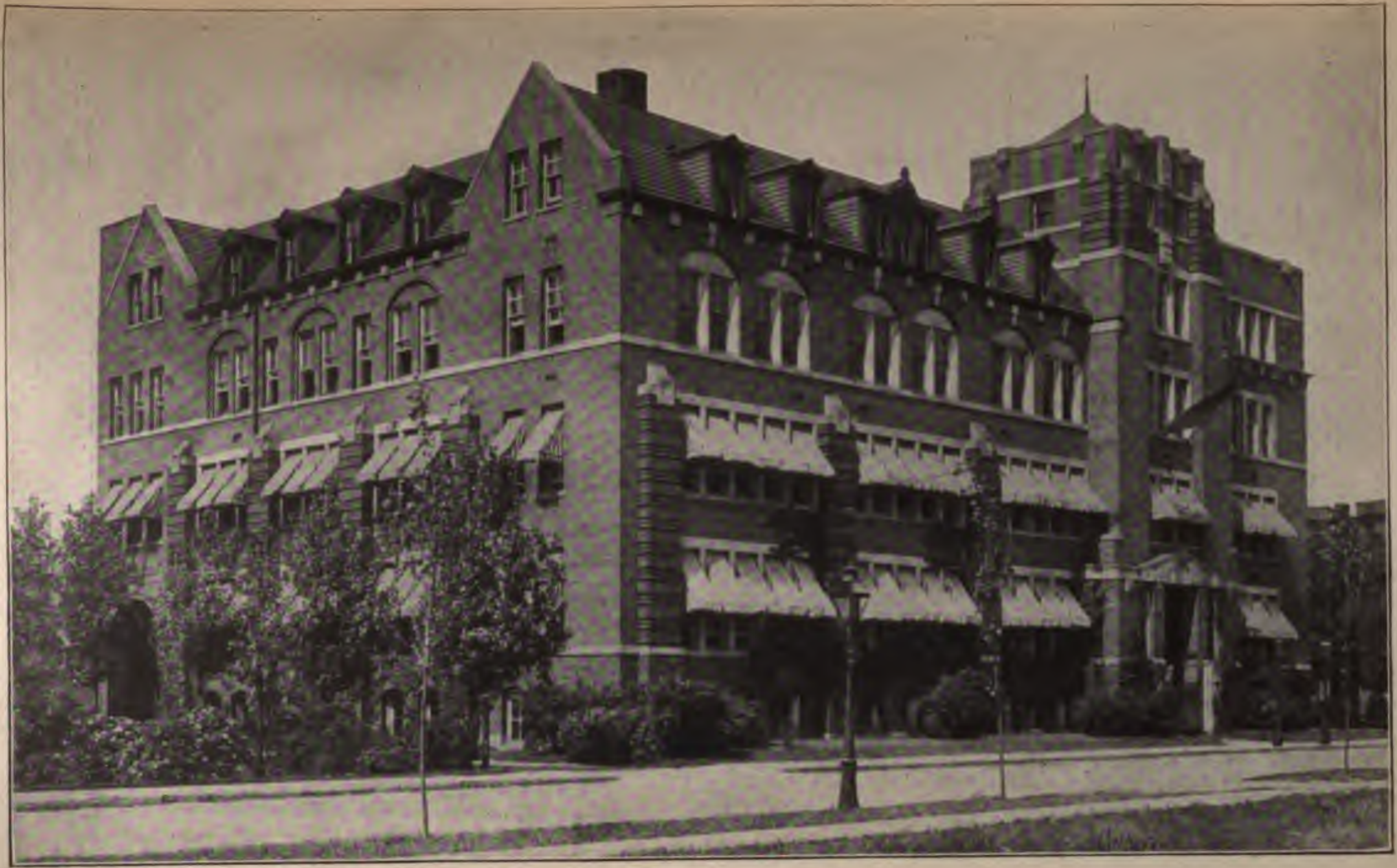
Before putting the stair together, be sure that it can be taken into the house and put in position without trouble. If for any reason it cannot be put in after being put together, then the parts must be assembled, wedged, and glued up at the spot.

It is essential in laying out a plan on the floor, that the exact positions of the first and last risers be ascertained, and the height of the story wherein the stair is to be placed. Then draw a plan of the hall or other room in which the stairs will be located, including surrounding or adjoining parts of the room to the extent of ten or twelve feet from the place assigned for the foot of the stair. All the doorways, branching passages, or windows which can possibly come in contact with the stair from its commencement to its expected termination or landing, must be noted. The sketch must necessarily include a portion of the entrance hall in one part, and of the lobby or landing in another, and on it must be laid out all the lines of the stair from the first to the last riser.

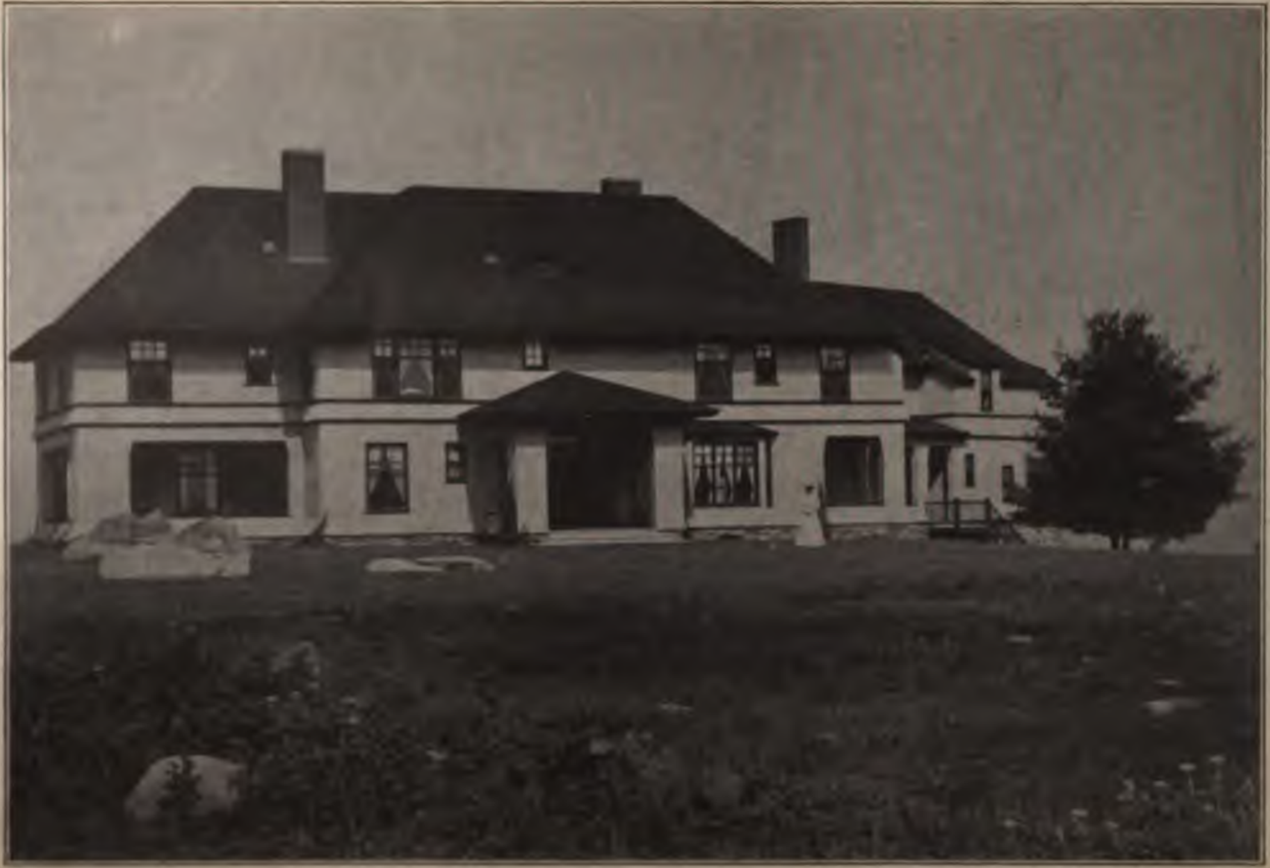
The height of the story must next be exactly determined and taken on the rod; then, assuming a height of risers suitable to the place, a trial is made by division in the manner previously explained, to ascertain how often this height is contained in the height of the story. The quotient, if there is no remainder, will be the number of risers required. Should there be a remainder on the first division, the operation is reversed, the number of inches in the height being made the dividend and the before-found quotient the divisor; and the operation of reduction by division is carried on till the height of the riser is obtained to the thirty-second part of an inch. These heights are then set off as exactly as possible on the story rod, as shown in Fig. 33.

The next operation is to show the risers on the sketch. This the workman will find no trouble in arranging, and no arbitrary rule can be given.

A part of the foregoing may appear to be repetition; but it is not, for it must be remembered that scarcely any two flights of stairs are alike in run, rise, or pitch, and any departure in any one dimension from these conditions leads to a new series of dimensions that must be dealt with independently. The principle laid down, however, applies to all straight flights of stairs; and the student who has followed



BUILDING FOR THE AMERICAN SCHOOL OF CORRESPONDENCE, CHICAGO, ILLINOIS
Pond and Pond, Architects, Chicago
Exterior of Brick in Two Colors with Stone Trimmings and Tile Roof



COUNTRY HOUSE AT BETHLEHEM, N. H.

closely and retained the pith of what has been said, will, if he has a fair knowledge of the use of tools, be fairly equipped for laying out and constructing a plain, straight stair with a straight rail.

Plain stairs may have one platform, or several; and they may turn to the right or to the left, or, rising from a platform or landing, may run in an opposite direction from their starting point.

When two flights are necessary for a story, it is desirable that each flight should consist of the same number of steps; but this, of course, will depend on the form of the staircase, the situation and height of doors, and other obstacles to be passed under or over, as the case may be.

In Fig. 32, a stair is shown with a single platform or landing and three newels. The first part of this stair corresponds, in number of risers, with the stair shown in Fig. 33; the second newel runs down to the floor, and helps to sustain the landing. This newel may simply by a 4 by 4-inch post, or the whole space may be inclosed with the spandrel of the stair. The second flight starts from the platform just as the first flight starts from the lower floor, and both flights may be attached to the newels in the manner shown in Fig. 29. The bottom tread in Fig. 32 is rounded off against the square of the newel post; but this cannot well be if the stairs start from the landing, as the tread would project too far onto the platform. Sometimes, in high-class stairs, provision is made for the first tread to project well onto the landing.

If there are more platforms than one, the principles of construction will be the same; so that whenever the student grasps the full conditions governing the construction of a single-platform stair, he will be prepared to lay out and construct the body of any stair having one or more landings. The method of laying out, making, and setting up a hand-rail will be described later.

Stairs formed with treads each of equal width at both ends, are named *straight flights*; but stairs having treads wider at one end than the other are known by various names, as *winding stairs, dog-legged stairs, circular stairs*, or *elliptical stairs*. A tread with parallel sides, having the same width at each end, is called a *flyer;* while one having one wide end and one narrow, is called a *winder*. These terms will often be made use of in what follows.

The elevation and plan of the stair shown in Fig. 34 may be called a *dog-legged* stair with three winders and six flyers. The flyers, however, may be extended to any number. The housed strings to receive the winders are shown. These strings show exactly the manner of construction. The shorter string, in the corner from 1 to 4, which is shown in the plan to contain the housing of the first winder and half of the second, is put up first, the treads being leveled by aid of a spirit level; and the longer upper string is put in place afterwards, butting snugly against the lower string in the corner. It is then fastened firmly to the wall. The winders are cut snugly around the newel post, and well nailed. Their risers will stand one above another on the post; and the straight string above the winders will enter the post on a line with the top edge of the uppermost winder.

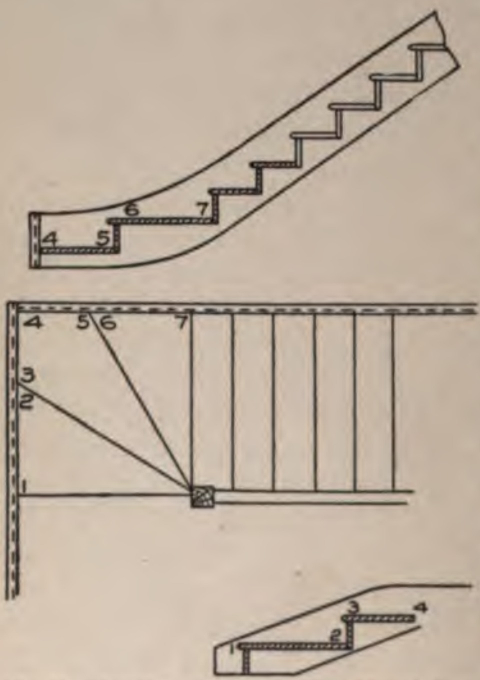


Fig. 34. Elevation and Plan of Dog-Legged Stair with Three Winders and Six Flyers.

Platform stairs are often constructed so that one flight will run in a direction opposite to that of the other flight, as shown in Fig. 35. In cases of this kind, the landing or platform requires to have a length more than double that of the treads, in order that both flights may have the same width. Sometimes, however, and for various reasons, the upper flight is made a little narrower than the lower; but this expedient should be avoided whenever possible, as its adoption unbalances the stairs. In the example before us, eleven treads, not including the landing, run in one direction; while four treads, including the landing, run in the opposite direction; or, as workmen put it, the stair "returns on itself." The elevation

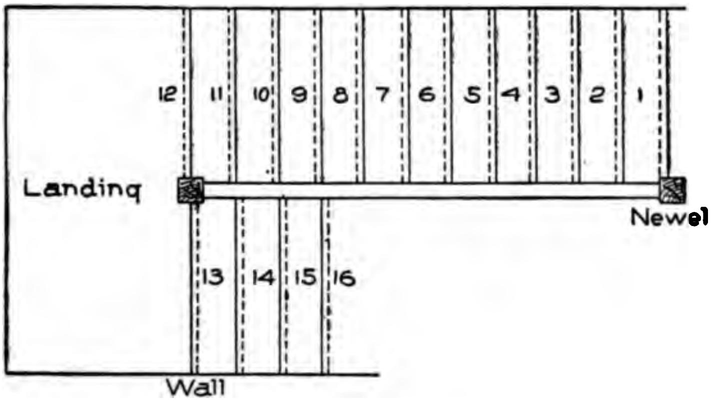


Fig. 35. Plan of Platform Stair Returning on Itself.

shown in Fig. 36 illustrates the manner in which the work is executed. The various parts are shown as follows:

Fig. 37 is a section of the top landing, with baluster and rail.

Fig. 38 is part of the long newel, showing mortises for the strings.

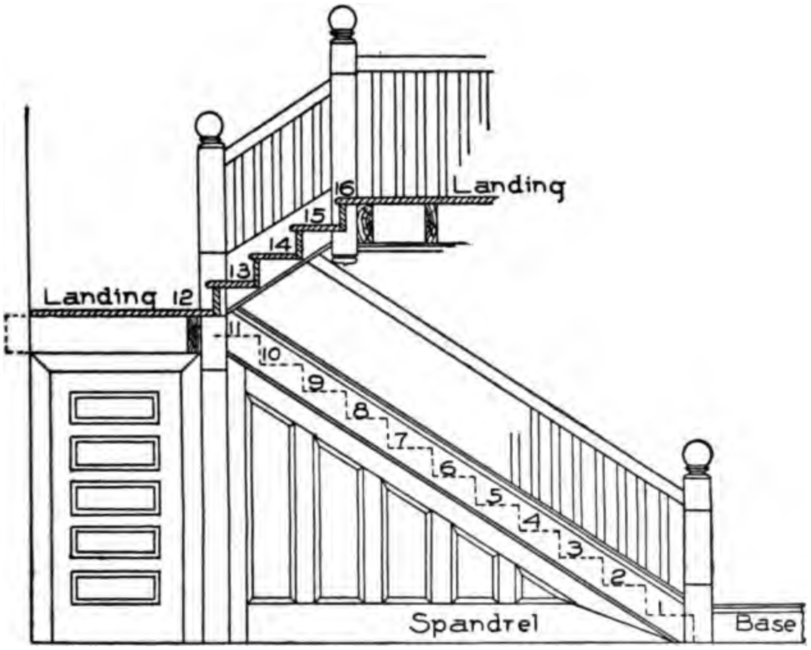


Fig. 36. Elevation Showing Construction of Platform Stair of which Plan is Given in Fig. 35.

Fig. 39 represents part of the bottom newel, showing the string, moulding on the outside, and cap.

Fig. 40 is a section of the top string enlarged.

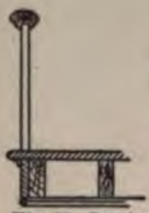


Fig. 37. Section of Top Landing, Baluster, and Rail.

Fig. 41 is the newel at the bottom, as cut out to receive bottom step. It must be remembered that there is a *cove* under each tread. This may be nailed in after the stairs are put together, and it adds greatly to the appearance.

We may state that stairs should have *carriage pieces* fixed from floor to floor, under the stairs, to support them. These may be notched under the steps; or *rough brackets* may be nailed to the side of the carriage, and carried under each riser and tread.

There is also a framed spandrel which helps materially to carry the weight, makes a sound job, and adds greatly to the appearance. This spandrel may be made of 1¼-inch material, with panels and mouldings on the front side, as shown in Fig. 36. The joint between the top and bottom rails of the spandrel at the angle, should be made as shown in Fig. 42 with a cross-tongue, and glued and fastened with long screws. Fig. 43 is simply one of the panels showing the miters on the moulding and the shape of the sections. As there is a convenient space under the landing, it is commonly used for a closet.

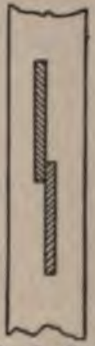


Fig. 38. String Mortises in Long Newel.

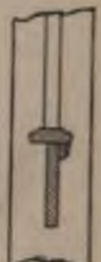


Fig. 39. Mortises in Lower Newel for String, Outside Moulding and Cap.

In setting out stairs, not only the proportions of treads and risers must be considered, but also the material available. As this material runs, as a rule, in certain sizes, it is best to work so as to conform to it as nearly as possible. In ordinary stairs, 11 by 1-inch common stock is used for strings and treads, and 7-inch by ¾-inch stock for risers; in stairs of a better class, wider and thicker material may be used. The rails are set at various heights; 2 feet 8 inches may be

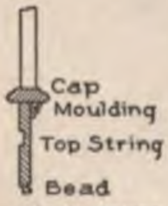


Fig. 40. Enlarged Section of Top String.

taken as an average height on the stairs, and 3 feet 1 inch on landings, with two balusters to each step.

In Fig. 36, all the newels and balusters are shown square; but it is much better, and is the more common practice, to have them turned, as this gives the stairs a much more artistic appearance. The spandrel under the string of the stairway shows a style in which many stairs are finished in hallways and other similar places. Plaster is sometimes used instead of the panel work, but is not nearly so good as woodwork. The door under the landing may open into a closet, or may lead to a cellarway, or through to some other room.

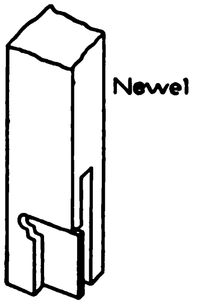


Fig. 41. Newel Cut to Receive Bottom Step.

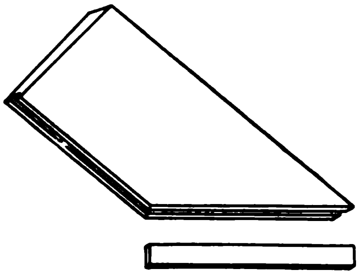


Fig. 42. Showing Method of Joining Spandrel Rails, with Cross-Tongue Glued and Screwed.

In stairs with winders, the width of a winder should, if possible, be nearly the width of the regular tread, at a distance of 14 inches from the narrow end, so that the length of the step in walking up or down the stairs may not be interrupted; and for this reason and several others, it is always best to have three winders only in each quarter-turn. Above all, avoid a four-winder turn, as this makes a breakneck stair, which is more difficult to construct and inconvenient to use.

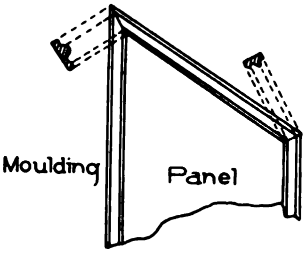


Fig. 43. Panel in Spandrel, Showing Miters on Moulding, and Shape of Section.

Bullnose Tread. No other stair, perhaps, looks so well at the starting point as one having a *bullnose* step. In Fig. 44 are shown a plan and elevation of a flight of stairs having a bullnose tread. The method of obtaining the lines and setting out the body of the stairs, is the same as has already been explained for other stairs, with the exception of the first two steps, which are made with circular ends, as shown in the plan. These circular ends are worked out as hereafter described, and are attached to the newel and string as shown.

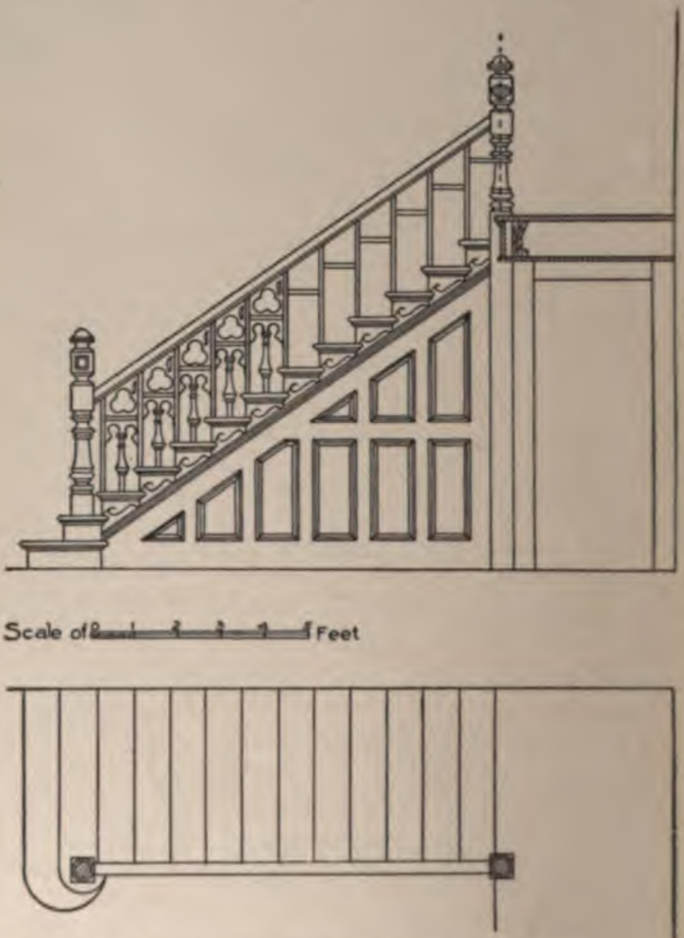


Fig. 44. Elevation and Plan of Stair with Bullnose Tread.

The example shows an open, cut string with brackets. The spandrel under the string contains short panels, and makes a very handsome finish. The newels and balusters in this case are turned, and the latter have cutwork panels between them.

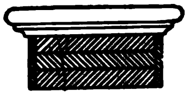


Fig. 45. Section through Bullnose Step.

Bullnose steps are usually built up with a three-piece block, as shown in Fig. 45, which is a section through the step indicating the blocks, tread, and riser.

Fig. 46 is a plan showing how the veneer of the riser is prepared before being bent into position. The block *A* indicates a wedge which is glued and driven home after the veneer is put in place. This tightens up the work and makes it sound and clear. Figs. 47 and 48 show other methods of forming bullnose steps.

Fig. 49 is the side elevation of an open-string stair with bullnose steps at the bottom; while Fig. 50 is a view showing the lower end of the string, and the manner in which it is prepared for fixing to the blocks of the step. Fig. 51 is a section through the string, showing the bracket, cove, and projection of tread over same.

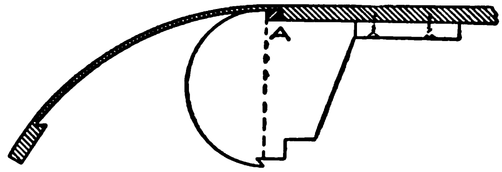


Fig. 46. Plan Showing Preparation of Veneer before Bending into Position.

Figs. 52 and 53 show respectively a plan and vertical section of the bottom part of the stair. The blocks are shown at the ends of the steps (Fig. 53), with the veneered parts of the risers going round them; also the position where the string is fixed to the blocks (Fig. 52); and the tenon of the newel is marked on the upper step. The section (Fig. 53) shows the manner in which the blocks are built up and the newel tenoned into them.

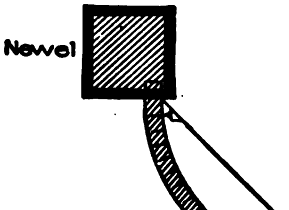


Fig. 47.

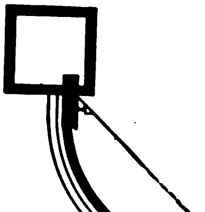


Fig. 48.

Methods of Forming Bullnose Steps.

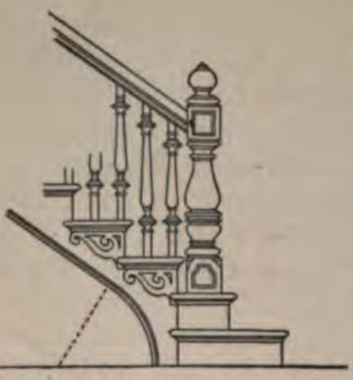


Fig. 49. Side Elevation of Open-String Stair with Bullnose Steps.

The newel, Fig. 49, is rather an elaborate affair, being carved at the base and on the body, and having a carved rosette planted in a small, sunken panel on three sides, the rail butting against the fourth side.

Open-Newel Stairs. Before leaving the subject of straight and dog-legged stairs, the student should be made familiar with at least one example of an open-newel stair. As the same principles of construction govern all styles of open-newel stairs, a single example will be sufficient. The student must, of course, understand that he himself is the greatest factor in planning stairs of this type; that the setting out and designing will generally devolve on him. By exercising a little thought and foresight, he can so arrange his plan that a minimum of both labor and material will be required.

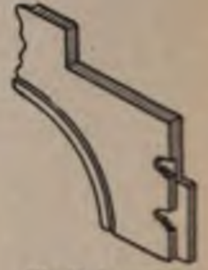


Fig. 50. Lower End of String to Connect with Bullnose Step.

Fig. 54 shows a plan of an open-newel stair having two landings and closed strings, shown in elevation in Fig. 55. The dotted lines show the carriage timbers and trimmers, also the lines of risers; while the treads are shown by full lines. It will be noticed that the strings and trimmers at the first landing are framed into the shank of the second newel post, which runs down to the floor; while the top newel drops below the fascia, and has a turned and carved drop. This drop hangs below both the fascia and the string. The lines of treads and risers are shown by dotted lines and crosshatched sections. The position of the carriage timbers is shown both in the landings and in the runs of the stairs, the projecting ends of these timbers being supposed to be resting on the wall. A scale of the plan and elevation is attached to the plan. In Fig. 55, a story rod is shown at the right, with the number of risers spaced off thereon. The design of the newels, spandrel, framing, and paneling is shown.

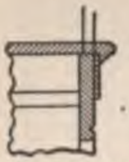


Fig. 51. Section through String.

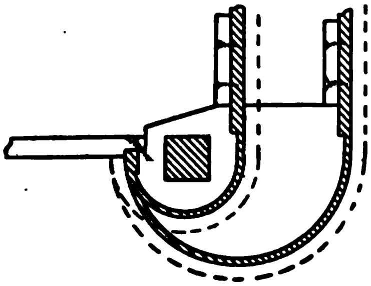


Fig. 52. Plan of Bottom Part of Bullnose Stair

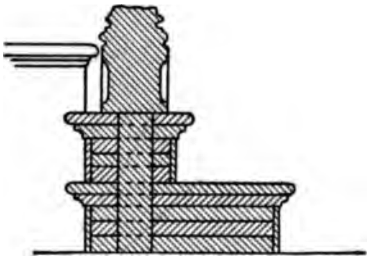


Fig. 53. Vertical Section through Bottom Part of Bullnose Stair.

Only the central carriage timbers are shown in Fig. 54; but in a stair of this width, there ought to be two other timbers, not so heavy, perhaps, as the central one, yet strong enough to be of service in lending additional strength to the stairway, and also to help carry the laths and plaster or the paneling which may be necessary in completing the under side or soffit. The strings being closed, the butts of their balusters must rest on a subrail which caps the upper edge of the outer string.

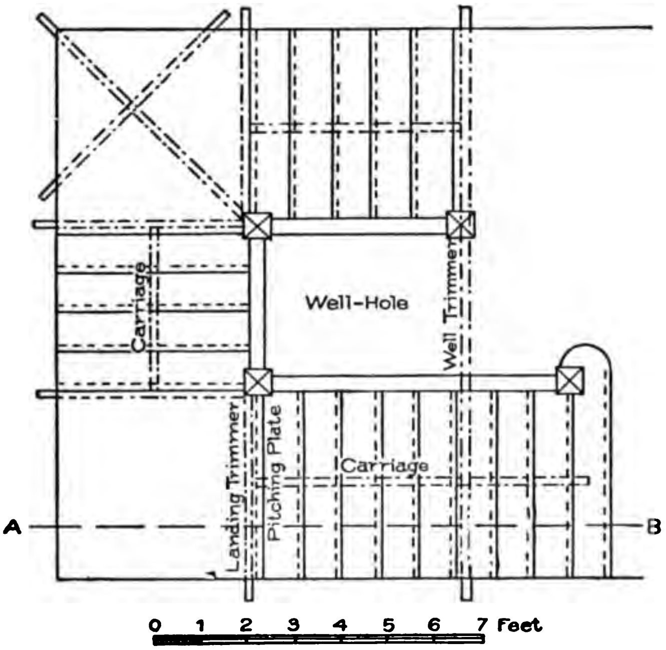


Fig. 54. Plan of Open-Newel Stair, with Two Landings and Closed Strings.

The first newel should pass through the lower floor, and, to insure solidity, should be secured by bolts to a joist, as shown in the elevation. The rail is attached to the newels in the usual manner, with handrail bolts or other suitable device. The upper newel should be made fast to the joists as shown, either by bolts or in some other efficient manner. The intermediate newels are left square on the shank below the stairs, and may be fastened in the floor below either by mortise and tenon or by making use of joint bolts.

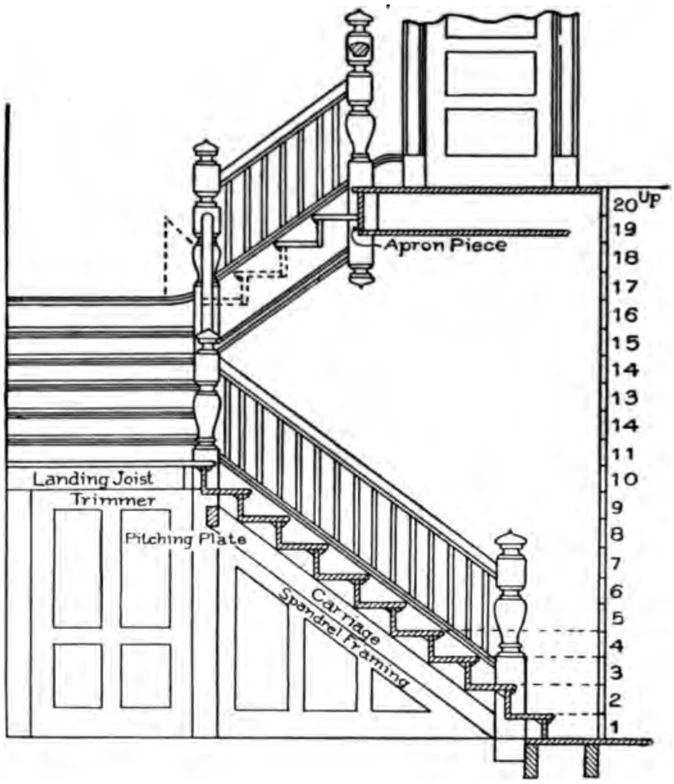


Fig. 55. Elevation of Open-Newel Stair Shown in Plan in Fig. 54.

Everything about a stair should be made solid and sound; and every joint should set firmly and closely; or a shaky, rickety, squeaky stair will be the result, which is an abomination.

Stairs with Curved Turns. Sufficient examples of stairs having angles of greater or less degree at the turn or change of direction, to

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ASTOR, LENOX AND
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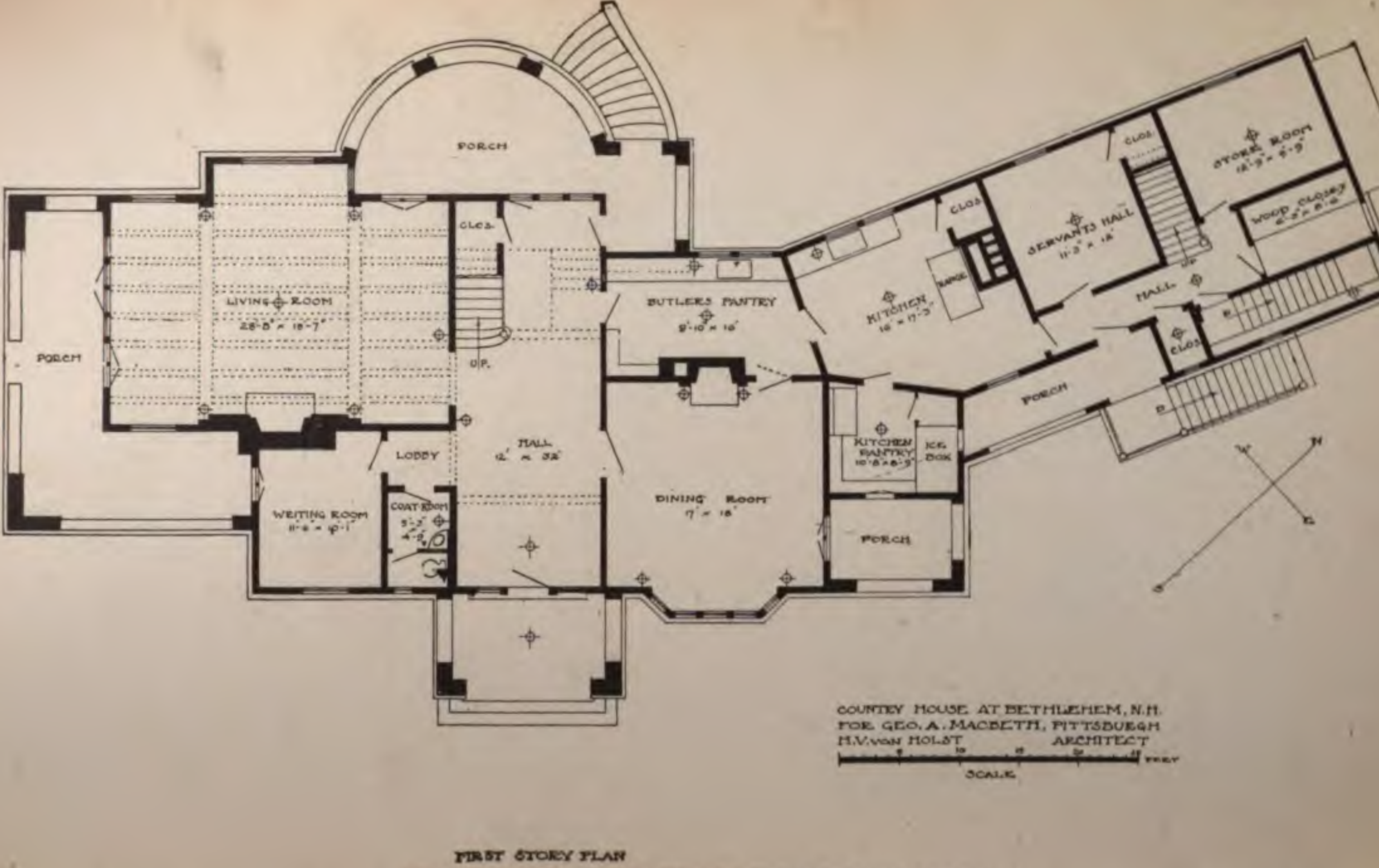
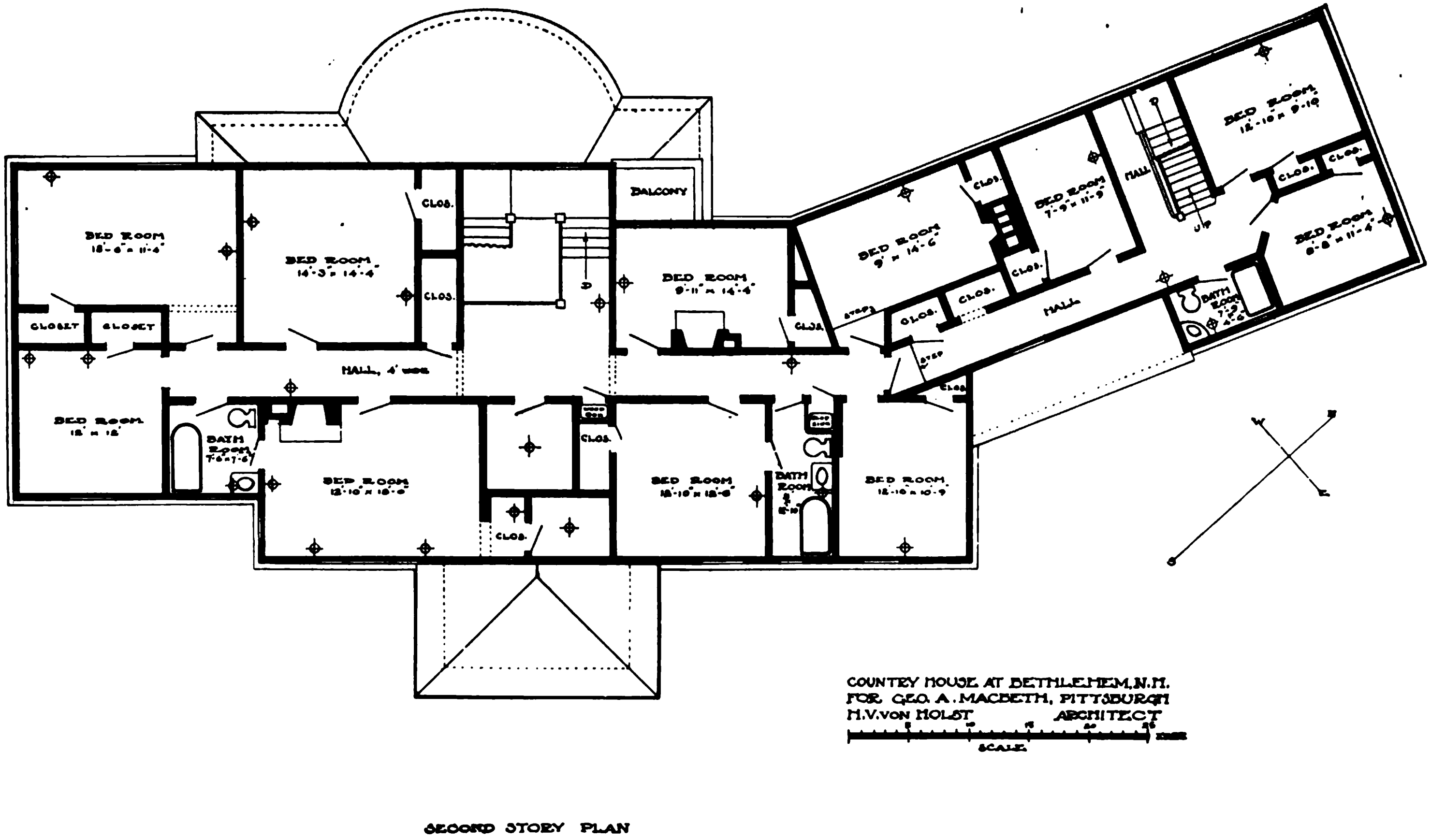


FIRST-STORY PLAN OF COUNTRY HOUSE AT BETHLEHEM, N. H.

The Living Room Affords a View into the Littleton Valley, to the Northwest. The View from the Dining Room is toward Mount Washington. The South Porch Looks Out on Mount Lafayette. Living Room Finished in Oak, Natural; Dining Room, Stair Hall, and Writing Room, in Cypress; Bedrooms in White Pine; Servants' Rooms in Georgia Pine. House Built in 1904-05. Cost, $11,000. For Exterior, See Page 288.



SECOND-STORY PLAN OF COUNTRY HOUSE AT BETHLEHEM, N. H.
First-Story Plan Shown on Opposite Page.

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enable/the student to build any stair of this class, have now been given. There are, however, other types of stairs in common use, whose turns are curved, and in which newels are employed only at the foot, and sometimes at the finish of the flight. These curved turns may be any part of a circle, according to the requirements of the case, but turns of a quarter-circle or half-circle are the more common. The string forming the curve is called a *cylinder*, or part of a cylinder, as the case may be. The radius of this circle or cylinder may be any length, according to the space assigned for the stair. The opening around which the stair winds is called the *well-hole.*

Fig. 56 shows a portion of a stairway having a well-hole with a 7-inch radius. This stair is rather peculiar, as it shows a quarter-space landing, and a quarter-space having three winders. The reason for this is the fact that the landing is on a level with the floor of another room, into which a door opens from the landing. This is a problem very often met with in practical work, where the main stair is often made to do the work of two flights because of one floor being so much lower than another.

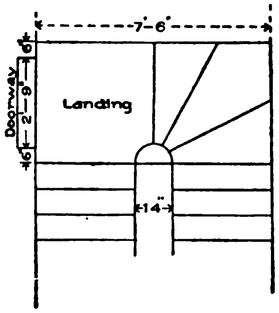

Fig. 56. Stair Serving for Two Flights, with Mid-Floor Landing.

A curved stair, sometimes called a *geometrical stair,* is shown in Fig. 57, containing seven winders in the cylinder or well-hole, the first and last aligning with the diameter.

In Fig. 58 is shown another example of this kind of stair, containing nine winders in the well-hole, with a circular wall-string. It is not often that stairs are built in this fashion, as most stairs having a circular well-hole finish against the wall in a manner similar to that shown in Fig. 57.

Sometimes, however, the workman will be confronted with a plan such as shown in Fig. 58; and he should know how to lay out the wall-string. In the elevation, Fig. 58, the string is shown to be straight, similar to the string of a common straight flight. This results from having an equal width in the winders along the wall-string, and, as we have of necessity an equal width in the risers, the development of the string is merely a straight piece of board, as in an ordinary straight flight. In laying out the string, all we have to do is to make a common pitch-board, and, with it as a templet, mark the lines of the treads and risers on a straight piece of board, as shown at 1, 2, 3, 4, etc.

If you can manage to bend the string without kerfing (grooving), it will be all the better; if not, the kerfs (grooves) must be parallel to the rise. You can set out with a straight edge, full size, on a rough platform, just as shown in the diagram; and when the string is bent and set in place, the risers and winders will have their correct positions.

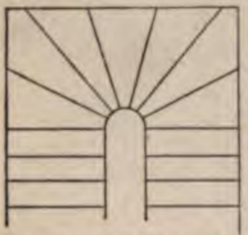

Fig. 57. Geometrical Stair with Seven Winders.

To bend these strings or otherwise prepare them for fastening against the wall, perhaps the easiest way is to saw the string with a fine saw, across the face, making parallel grooves. This method of bending is called *kerfing*, above referred to. The kerfs or grooves must be cut parallel to the lines of the risers, so as to be vertical when the string is in place. This method, however—handy though it may be—is not a good one, inasmuch as the saw groove will show more or less in the finished work.

Another method is to build up or *stave* the string. There are several ways of doing this. In one, comparatively narrow pieces are cut to the required curve or to portions of it, and are fastened together, edge to edge, with glue and screws, until the necessary width is obtained (see Fig. 59). The heading joints may be either butted or beveled, the latter being stronger, and should be cross-tongued.

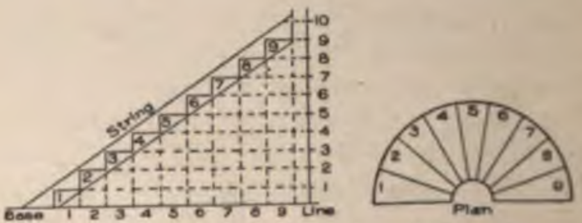

Fig. 58. Plan of Circular Stair and Layout of Wall String for Same.

Fig. 60 shows a method that may be followed when a wide string is required, or a piece curved in the direction of its width is needed for any purpose. The pieces are stepped over each other to suit the desired curve; and though shown square-edged in the figure, they are usually cut beveled, as then, by reversing them, two may be cut out of a batten.

Panels and quick sweeps for similar purposes are obtained in the manner shown in Fig. 61, by joining up narrow boards edge to edge at a suitable bevel to give the desired curve. The internal curve is frequently worked approximately, before gluing up. The numerous joints incidental to these methods limit their uses to painted or unimportant work.

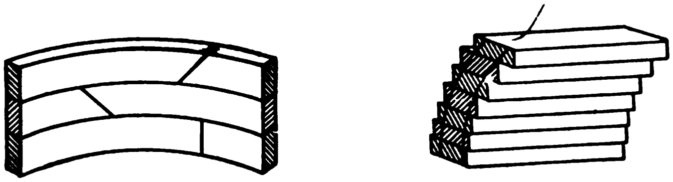

Fig. 59. Fig. 60.
Methods of Building Up Strings.

In Fig. 62 is shown a wreath-piece or curved portion of the outside string rising around the cylinder at the half-space. This is formed by reducing a short piece of string to a veneer between the springings; bending it upon a cylinder made to fit the plan; then, when it is secured in position, filling up the back of the veneer with staves glued across it; and, finally, gluing a piece of canvas over the whole. The appearance of the wreath-piece after it has been built up and removed from the cylinder is indicated in Fig. 63. The canvas back has been omitted to show the staving; and the counter-wedge key used for connecting the wreath-piece with the string is shown. The wreath-piece is, at this stage, ready for marking the outlines of the steps.

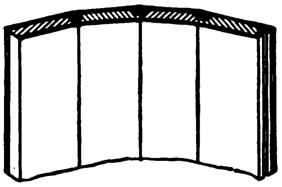

Fig. 61. Building Up a Curved Panel or Quick Sweep.

Fig. 62 also shows the drum or shape around which strings may be bent, whether the strings are formed of veneers, staved, or kerfed. Another drum or shape is shown in Fig. 64. In this, a portion of a cylinder is formed in the manner clearly indicated; and the string, being set out on a veneer board sufficiently thin to bend easily, is laid down round the curve, such a number of pieces of like thickness being then added as will make the required thickness of the string. In working this method, glue is introduced between the veneers, which are then quickly strained down to the curved piece with hand screws. A string of almost any length can be formed in this way, by gluing a few feet at a time, and when that dries, removing the cylindrical curve and gluing down more, until the whole is completed. Several other methods will suggest themselves to the workman, of building up good, solid, circular strings.

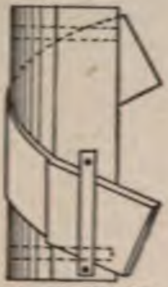

Fig. 62. Wreath-Piece Bent around Cylinder.

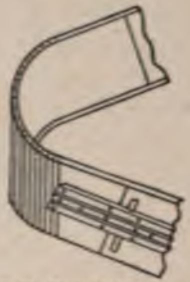

Fig. 63. Completed Wreath-Piece Removed from Cylinder.

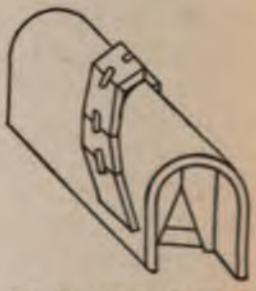

Fig. 64. Another Drum or Shape for Building Curved Strings.

One method of laying out the treads and risers around a cylinder or drum, is shown in Fig. 65. The line *D* shows the curve of the rail. The lines showing treads and risers may be marked off on the cylinder, or they may be marked off after the veneer is bent around the drum or cylinder.

There are various methods of making inside cylinders or wells, and of fastening same to strings. One method is shown in Fig. 66. This gives a strong joint when properly made. It will be noticed that the cylinder is notched out on the back; the two blocks shown at the back of the offsets are wedges driven in to secure the cylinder in place, and to drive it up tight to the strings. Fig. 67 shows an 8-inch well-hole with cylinder complete; also the method of trimming and finishing same. The cylinder, too, is shown in such a manner that its construction will be readily understood.

Stairs having a cylindrical or circular opening always require a weight support underneath them. This support, which is generally made of rough lumber, is called the *carriage*, because it is supposed to carry any reasonable load that may be placed upon the stairway. Fig. 68 shows the under side of a half-space stair having a carriage beneath it. The timbers marked *S* are of rough stuff, and may be 2-inch by 6-inch or of greater dimensions. If they are cut to fit the risers and treads, they will require to be at least 2-inch by 8-inch.

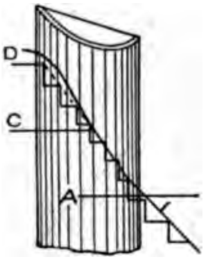

Fig. 65. Laying Out Treads and Risers around a Drum.

In preparing the rough carriage for the winders, it will be best to let the back edge of the tread project beyond the back of the riser so that it forms a ledge as shown under *C* in Fig. 69. Then fix the cross-carriage pieces under the winders, with the back edge about flush with the backs of risers, securing one end to the well with screws, and the other to the wall string or the wall. Now cut short pieces, marked *O O* (Fig. 68), and fix them tightly in between the cross-carriage and the back of the riser as at *B B* in the section, Fig. 69. These carriages should be of 3-inch by 2-inch material. Now get a piece of wood, 1-inch by 3-inch, and cut pieces *C C* to fit tightly between the top back edge of the winders (or the ledge) and the pieces marked *B B* in section. This method makes a very sound and strong job of the winders; and if the stuff is roughly planed, and blocks are glued on each side of the short cross-pieces *O O O*, it is next to impossible for the winders ever to spring or squeak. When the weight is carried in this manner, the plasterer will have very little trouble in lathing so that a graceful soffit will be made under the stairs.

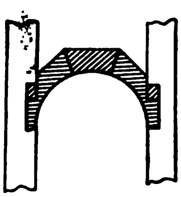

Fig. 66. One Method of Making an Inside Well.

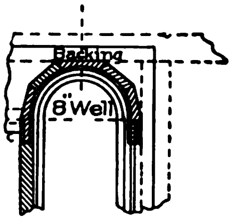

Fig. 67. Construction and Trimming of 8-Inch Well-Hole.

The manner of placing the main stringers of the carriage *S S*, is shown at *A*, Fig. 69. Fig. 68 shows a complete half-space stair:

one-half of this, finished as shown, will answer well for a quarter-space stair.

Another method of forming a carriage for a stair is shown in Fig. 70. This is a peculiar but very handsome stair, inasmuch as the first and the last four steps are parallel, but the remainder *balance* or *dance*. The treads are numbered in this illustration; and the plan of the handrail is shown extending from the scroll at the bottom of the stairs to the landing on the second story. The trimmer *T* at the top of the stairs is also shown; and the rough strings or carriages, *R S*, *R S*, *R S*, are represented by dotted lines.

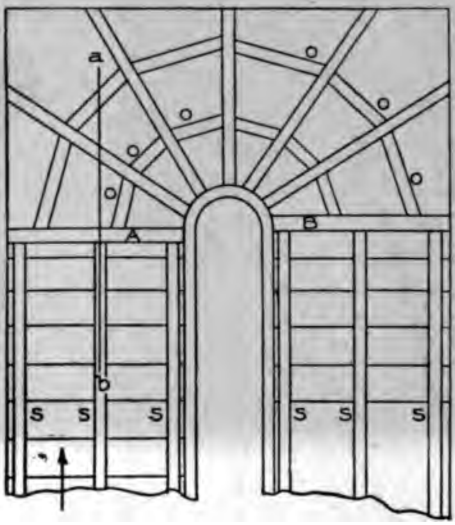

Fig. 68. Under Side of Half-Space Stair, with Carriages and Cross-Carriages.

This plan represents a stair with a curtail step, and a scroll handrail resting over the curve of the curtail step. This type of stair is not now much in vogue in this country, though it is adopted occasionally in some of the larger cities. The use of heavy newel posts instead of curtail steps, is the prevailing style at present.

In laying out geometrical stairs, the steps are arranged on principles already described. The well-hole in the center is first laid down and the steps arranged around it. In circular stairs with an open well-hole, the handrail being on the inner side, the width of tread for the steps should be set off at about 18 inches from the handrail, this giving an approximately uniform rate of progress for anyone ascending or descending the stairway. In stairs with the rail on the outside, as sometimes occurs, it will be sufficient if the treads have the proper width at the middle point of their length.

Where a flight of stairs will likely be subject to great stress and wear, the carriages should be made much heavier than indicated in the foregoing figures; and there may be cases when it will be necessary to use iron bolts in the sides of the rough strings in order to give them greater strength. This necessity, however, will arise only in the case of stairs built in public buildings, churches, halls, factories, warehouses, or other buildings of a similar kind. Sometimes, even in house stairs, it may be wise to strengthen the treads and risers by spiking pieces of board to the rough string, ends up, fitting them snugly against the under side of the tread and the back of the riser. The method of doing this is shown in Fig. 71, in which the letter *O* shows the pieces nailed to the string.

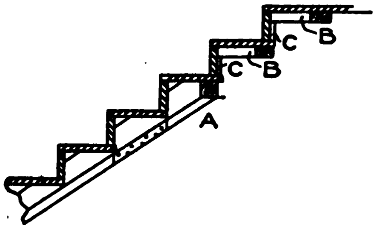

Fig. 69. Method of Reinforcing Stair.

Types of Stairs in Common Use. In order to make the student familiar with types of stairs in general use at the present day, plans of a few of those most likely to be met with will now be given.

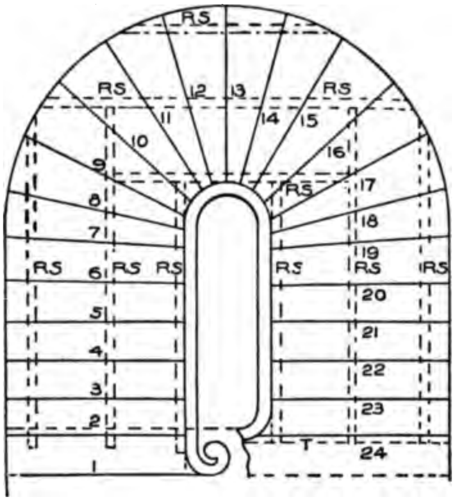

Fig. 70. Plan Showing One Method of Constructing Carriage and Trimming Winding Stair.

Fig. 72 is a plan of a straight stair, with an ordinary cylinder at the top provided for a return rail on the landing. It also shows a stretch-out stringer at the starting.

Fig. 73 is a plan of a stair with a landing and return steps.

Fig. 74 is a plan of a stair with an acute angular landing and cylinder.

Fig. 75 illustrates the same kind of stair as Fig. 74, the angle, however, being obtuse.

Fig. 76 exhibits a stair having a half-turn with two risers on landings.

Fig. 77 is a plan of a quarter-space stair with four winders.

Fig. 78 shows a stair similar to Fig. 77, but with six winders.

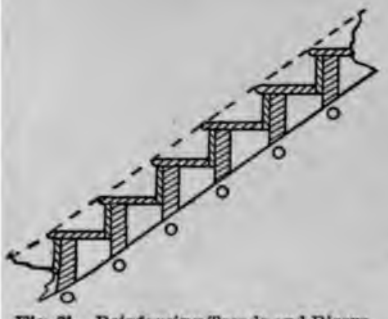

Fig. 71. Reinforcing Treads and Risers by Blocks Nailed to String.

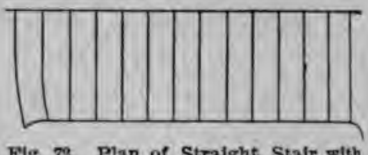

Fig. 72. Plan of Straight Stair with Cylinder at Top for Return Rail.

Fig. 79 shows a stair having five dancing winders.

Fig. 80 is a plan of a half-space stair having five dancing winders and a quarter-space landing.

Fig. 81 shows a half-space stair with dancing winders all around the cylinder.

Fig. 82 shows a geometrical stair having winders all around the cylinder.

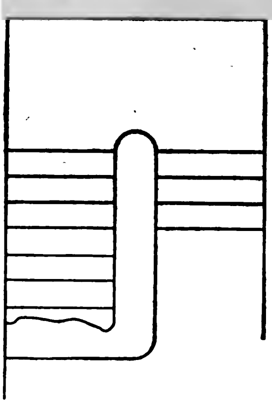

Fig. 73. Plan of Stair with Landing and Return Steps.

Fig. 83 shows the plan and elevation of stairs which turn around a central post. This kind of stair is frequently used in large stores and in clubhouses and other similar places, and has a very graceful appearance. It is not very difficult to build if properly planned.

The only form of stair not shown which the student may be called upon to build, would very likely be one having an elliptical plan; but, as this form is so seldom used—being found, in fact, only in public buildings or great mansions—it rarely falls to the lot of the ordinary workman to be called upon to design or construct a stairway of this type.

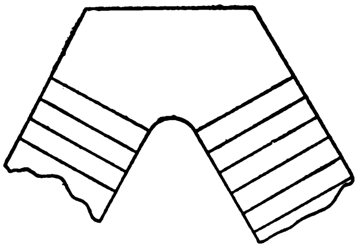

Fig. 74. Plan of Stair with Acute-Angle Landing and Cylinder.

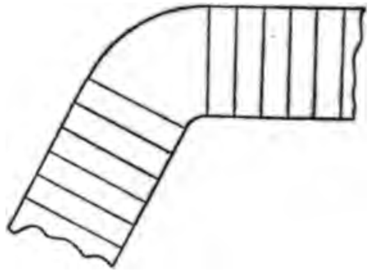

Fig. 75. Plan of Stair with Obtuse-Angle Landing and Cylinder.

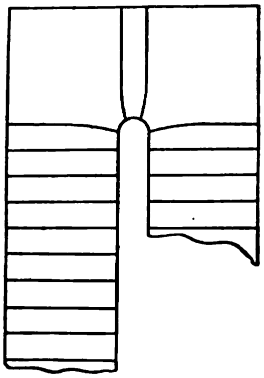

Fig. 76. Half-Turn Stair with Two Risers on Landings.

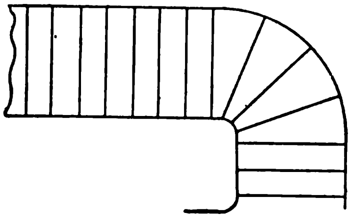

Fig. 77. Quarter-Space Stair with Four Winders.

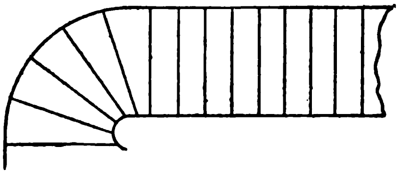

Fig. 79. Stair with Five Dancing Winders.

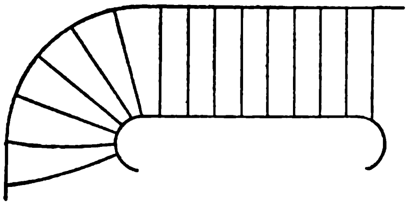

Fig. 78. Quarter-Space Stair with Six Winders.

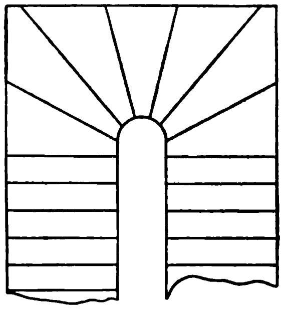

Fig. 81. Half-Space Stair with Dancing Winders all around Cylinder.

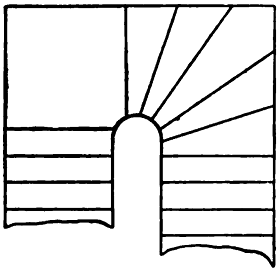

Fig. 80. Half-Space Stair with Five Dancing Winders and Quarter-Space Landing.

GEOMETRICAL STAIRWAYS AND HANDRAILING

The term *geometrical* is applied to stairways having any kind of curve for a plan. The rails over the steps are made continuous from one story to another. The resulting winding or twisting pieces are called *wreaths*.

Wreaths. The construction of wreaths is based on a few geometrical problems—namely, the projection of straight and curved lines into an oblique plane; and the finding of the angle of inclination of the plane into which the lines and curves are projected. This angle

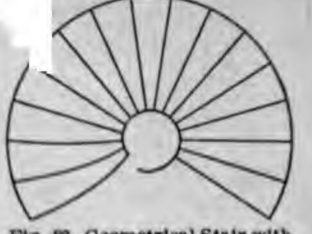

Fig. 82. Geometrical Stair with Winders all Around Cylinder.

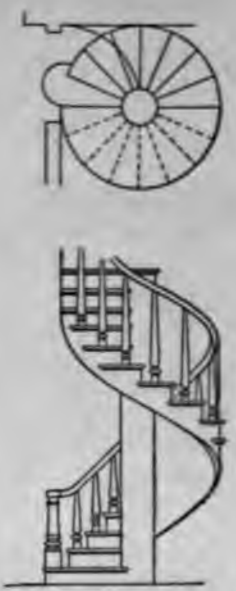

Fig. 83. Plan and Elevation of Stairs Turning around a Central Post.

is called the *bevel*, and by its use the wreath is made to

In Fig. 84 is sho -angle plan; in Fig. 85, plan; and in Fig. 86, a semicircle enclosed within straight lines.

Projection. A knowledge of h to project the lines and curves in e of these plans into an oblique plane, and to find the angle of inclination of the plane, will enable the student to construct any and all kinds of wreaths.

The straight lines *a, b, c, d* in the plan, Fig. 86, are known as *tangents;* and the curve, the *central line* of the plan wreath.

The straight line across from *n* to *n* is the *diameter;* and the perpendicular line from it to the lines *c* and *b* is the *radius.*

A *tangent* line may be defined as a line touching a curve without cutting it, and is made use of in handrailing to square the joints of the wreaths.

Tangent System. The *tangent system* of handrailing takes its name from the use made of the tangents for this purpose.

In Fig. 86, it is shown that the joints connecting the central line of rail with the plan rails *r* of the straight flights, are placed right at the springing; that is, they are in line with the diameter of the semicircle, and square to the side tangents *a* and *d*.

The center joint of the crown tangents is shown to be square to tangents *b* and *c*. When these lines are projected into an oblique plane, the joints of the wreaths can be made to butt square by applying the bevel to them.

All handrail wreaths are assumed to rest on an oblique plane while ascending around a well-hole, either in connecting two flights or in connecting one flight to a landing, as the case may be.

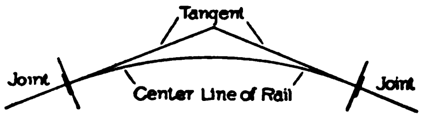

Fig. 84. Obtuse-Angle Plan.

In the simplest cases of construction, the wreath rests on an inclined plane that inclines in one direction only, to either side of the well-hole; while in other cases it rests on a plane that inclines to two sides.

Fig. 87 illustrates what is meant by a plane inclining in one direction. It will be noticed that the lower part of the figure is a reproduction of the quadrant enclosed by the tangents *a* and *b* in Fig. 86. The quadrant, Fig. 87, represents a central line of a wreath that is to ascend from the joint on the plan tangent *a* the height of *h* above the tangent *b*.

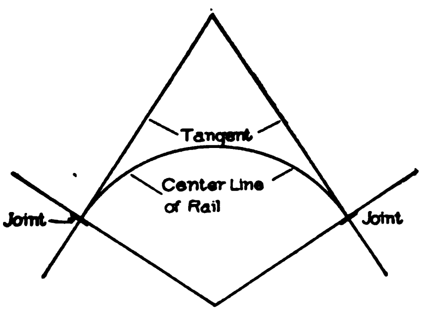

Fig. 85. Acute-Angle Plan.

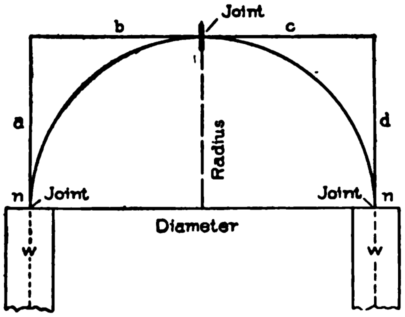

Fig. 86. Semicircular Plan.

In Fig. 88, a view of Fig. 87 is given in which the tangents *a* and *b* are shown in plan, and also the quadrant representing the plan central line of a wreath. The curved line extending from *a* to *h* in this figure represents the development of the central line of the plan wreath, and, as shown, it rests on an oblique plane inclining to one side only—namely, to the side of the plan tangent *a*. The joints are made square to the developed tangents *a* and *m* of the inclined plane; it is for this purpose only that tangents are made use of in wreath construction. They are shown in the figure to consist of two lines, *a* and *m*, which are two adjoining sides of a developed section (in this case, of a square prism), the section being the assumed inclined plane whereon the wreath rests in its ascent from *a* to *h*. The joint at *h*, if made square to the tangent *m*, will be a true, square butt-joint; so also will be the joint at *a*, if made square to the tangent *a*.

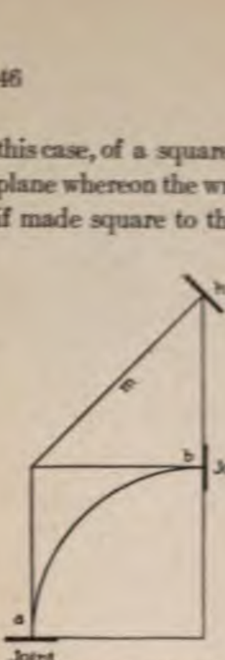

Fig. 87. Illustrating Plane Inclined in One Direction Only.

In practical work it will be required to find the correct goemetrical angle between the two developed tangents *a* and *m*; and here, again, it may be observed that the finding of the correct angle between the two developed tangents is the essential purpose of every tangent system of handrailing.

In Fig. 89 is shown the geometrical solution—the one necessary to find the angle between the tangents as required on the face-mould to square the joints of the wreath. The figure is shown to be similar to Fig. 87, except that it has an additional portion marked "Section." This section is the true shape of the oblique plane whereon the wreath ascends, a view of which is given in Fig. 88. It will be observed that one side of it is the developed tangent *m*; another side, the developed tangent a'' (= *a*). The angle between the two as here presented is the one required on the face-mould to square the joints.

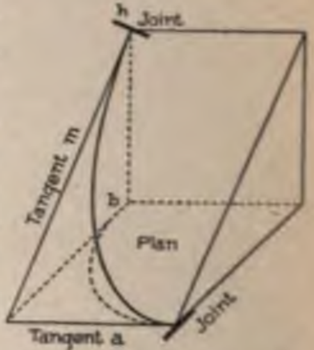

Fig. 88. Plan Line of Rail Projected into Oblique Plane Inclined to One Side Only.

In this example, Fig. 89, owing to the plane being oblique in one direction only, the shape of the section is found by merely drawing the tangent a'' at right angles to the tangent *m*, making it equal in length to the level tangent *a* in the plan. By drawing lines parallel to a'' and *m* respectively, the form of the section will be found, its outlines being the projections of the plan lines; and the angle between the two tangents, as already said, is the angle required on the face-mould to square the joints of the wreath.

The solution here presented will enable the student to find the correct direction of the tangents as required on the face-mould to square joints, in all cases of practical work where one tangent of a wreath is level and the other tangent is inclined, a condition usually met with in level-landing stairways.

Fig. 90 exhibits a condition of tangents where the two are equally inclined. The plan here also is taken from Fig. 86. The inclination of the tangents is made equal to the inclination of tangent *b* in Fig. 86, as shown at *m* in Figs. 87, 88, and 89.

In Fig. 91, a view of Fig. 90 is given, showing clearly the inclination of the tangents *c″* and *d″* over and above the plan tangents *c* and *d*. The central line of the wreath is shown extending along the sectional plane, over and above its plan lines, from one joint to the other, and, at the joints, made square to the inclined tangents *c″* and *d″*. It is evident from the view here given, that the condition necessary to square the joint at each end would be to find the true angle between the tangents *c″* and *d″*, which would give the correct direction to each tangent.

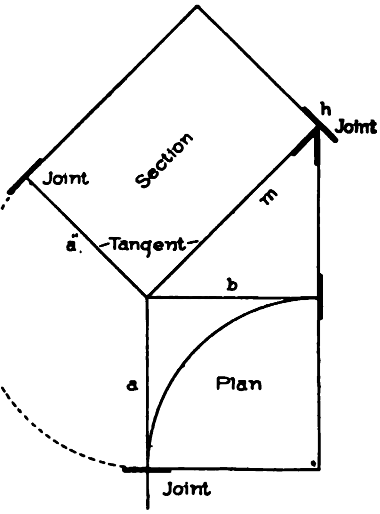

Fig. 89. Finding Angle between Tangents.

In Fig. 92 is shown how to find this angle correctly as required on the face-mould to square the joints. In this figure is shown the same plan as in Figs. 90 and 91, and the same inclination to the tangents as in Fig. 90, so that, except for the portion marked "Section," it would be similar to Fig. 90.

To find the correct angle for the tangents of the face-mould, draw the line *m* from *d*, square to the inclined line of the tangents *c′ d″*; revolve the bottom inclined tangent *c′* to cut line *m* in *n*, where the joint is shown fixed; and from this point draw the line *c″* to *w*. The intersection of this line with the upper tangent *d″* forms the correct angle as required on the face-mould. By drawing the joints square to these two lines, they will butt square with the rail that is to connect

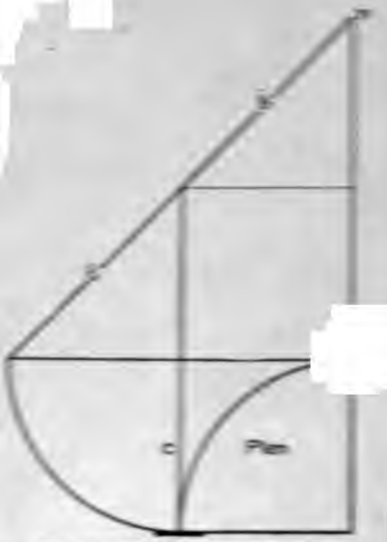

Fig. 90. Two Tangents Equally Inclined.

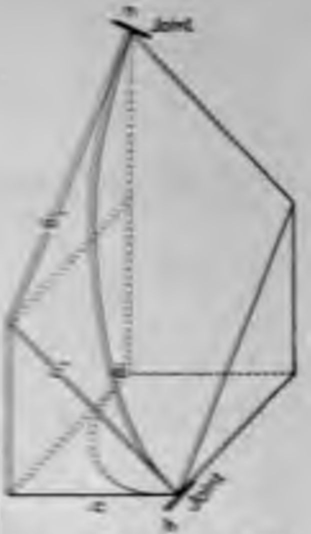

Fig. 91. Plan Lines Projected into Oblique Plane Inclined to Two Sides.

with them, or to the joint of another wreath that may belong to the cylinder or well-hole.

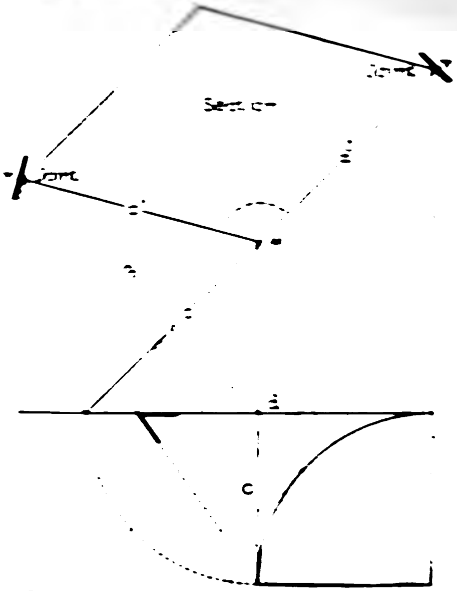

Fig. 92. Finding Angle between Tangents.

Fig. 92 is another view of these tangents in position placed over and above the plan tangents of the well-hole. It will be observed that this figure is made up of Figs. 88 and 91 combined. Fig. 88, as here presented, is shown to connect with a level-landing rail at a. The joint having been made square to the level tangent, a will butt square to a square end of the level rail. The joint at b is shown to connect the two wreaths and is made square to the inclined tangent m of the lower wreath, and also square to the inclined tangent c'' of the upper wreath; the two tangents, aligning, guarantee a square butt-joint. The upper joint is made square to the tangent d'', which is here shown to align with the rail of the connecting flight; the joint will consequently butt square to the end of the rail of the flight above.

The view given in this diagram is that of a wreath starting from a level landing, and winding around a well-hole, connecting the landing with a flight of stairs leading to a second story. It is presented to elucidate the use made of tangents to square the joints in wreath construction. The wreath is shown to be in two sections, one extending from the level-landing rail at a to a joint in the center of the well-hole at h, this section having one level tangent a and one inclined tangent m; the other section is shown to extend from h to n, where it is butt-jointed to the rail of the flight above.

This figure clearly shows that the joint at a of the bottom wreath—owing to the tangent a being level and therefore aligning with the level rail of the landing—will be a true butt-joint; and that the joint at h, which connects the two wreaths, will also be a true butt-joint, owing to it being made square to the tangent m of the bottom wreath and to the tangent c'' of the upper wreath, both tangents having the same inclination; also the joint at n will butt square to the rail of the flight above,

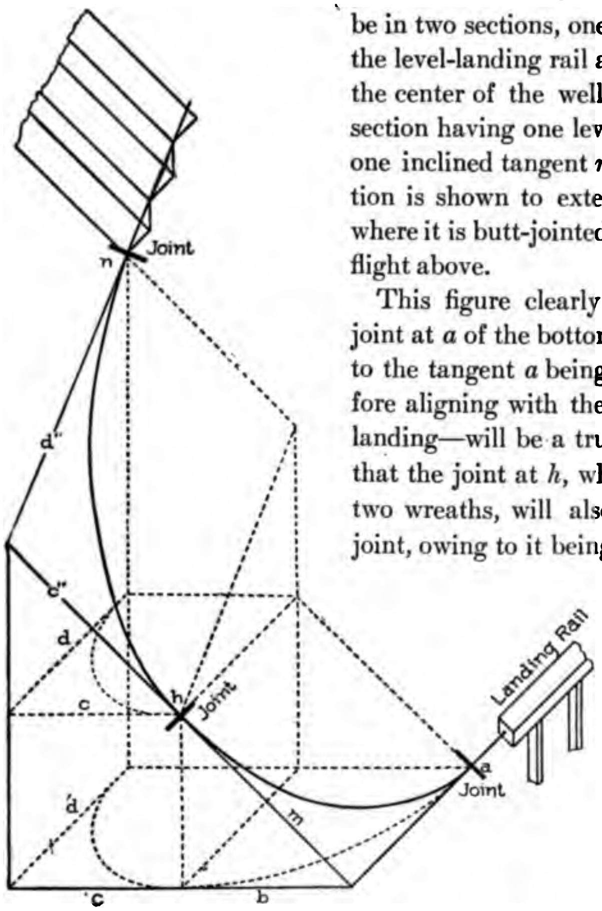

Fig. 98. Laying Out Line of Wreath to Start from Level-Landing Rail, Wind around Well-Hole, and Connect at Landing with Flight to Upper Story.

t being made square to the tangent d″, which is shown to
e ame inclination as the rail of the flight adjoining.

As previously stated, the use made of tangents is to square the
s of the wreaths; and in this diagram it is clearly shown that the
y they can be made of use is by giving each tangent its true direc-
n. How to find the true direction, or the angle between the tangents

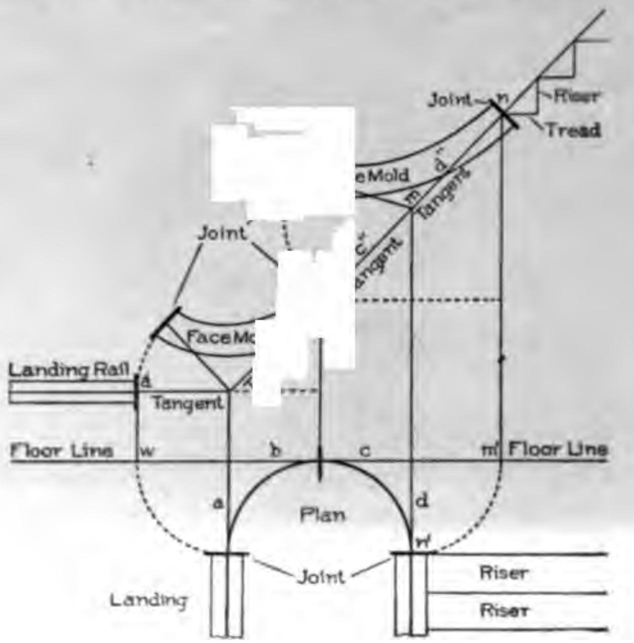

Fig. 94. Tangents Unfolded to Find Their Inclination.

a and m shown in this diagram, was demonstrated in Fig. 89; and how to find the direction of the tangents c″ and d″ was shown in Fig. 92.

Fig. 94 is presented to help further toward an understanding of the tangents. In this diagram they are unfolded; that is, they are stretched out for the purpose of finding the inclination of each one over and above the plan tangents. The side plan tangent *a* is shown stretched out to the floor line, and its elevation *a′* is a level line. The side plan tangent *d* is also stretched out to the floor line, as shown by the arc *n′ m′*. By this process the plan tangents are now in one straight line on the floor line, as shown from *w* to *m′*. Upon each one, erect a perpendicular line as shown, and from *m′* measure to *n*, the height the wreath is to ascend around the well-hole. In

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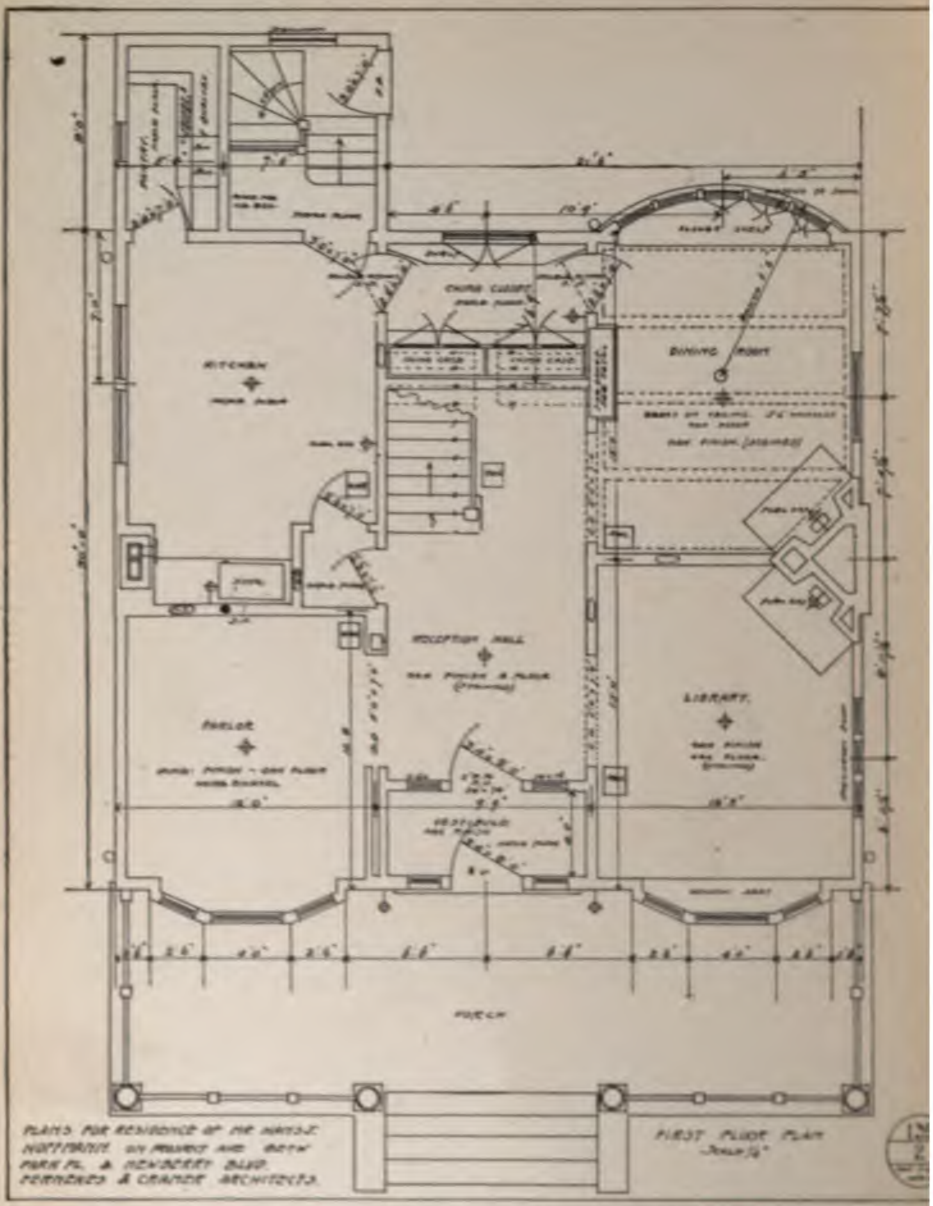
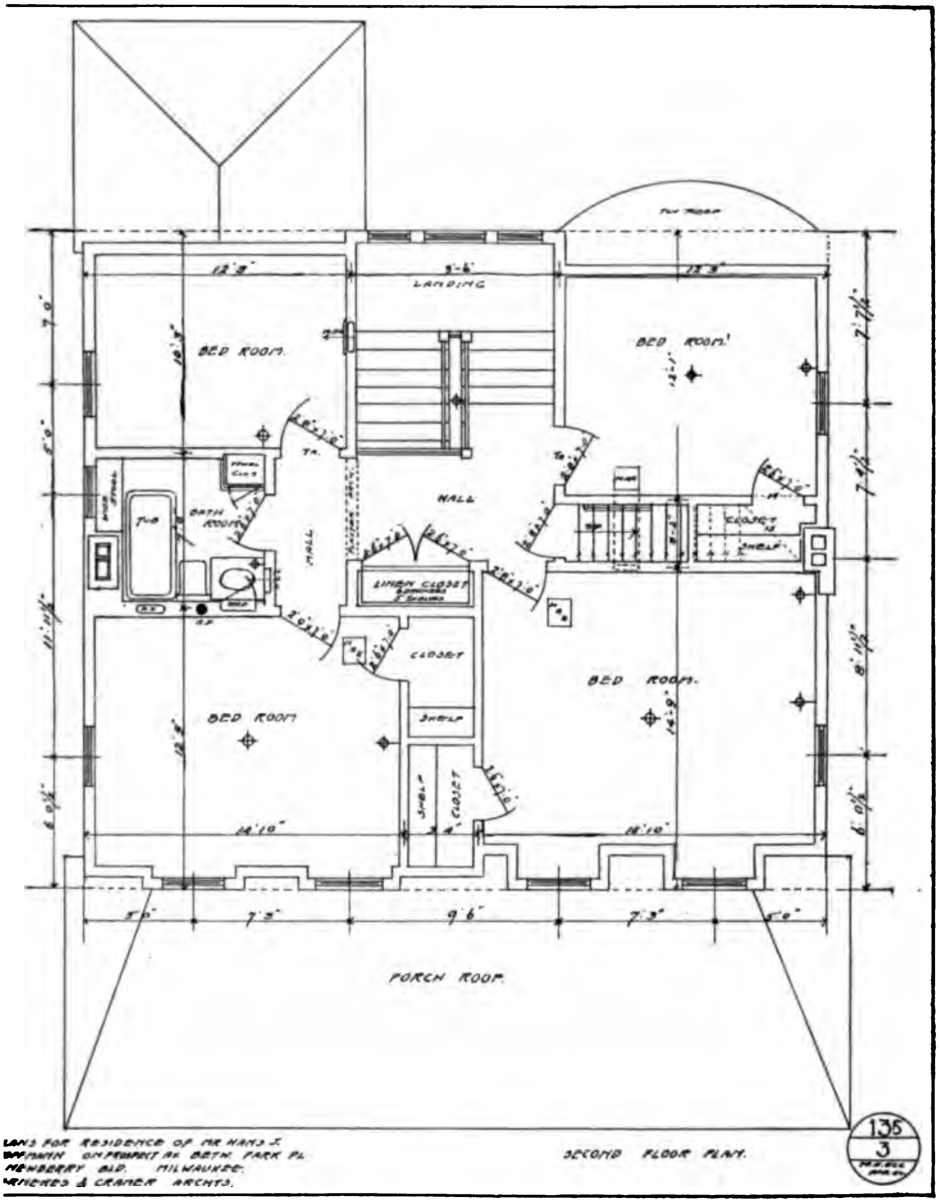


FIRST-FLOOR PLAN OF RESIDENCE FOR MR. HANS HOFFMAN, MILWAUKEE, WIS.

COST OF HOUSE:

Mason Work	$ 625.00	Heating (Furnace)	$ 167.00
Carpentry	2,684.00	Painting	225.00
Tinning	36.00	Decorating	52.00
Plumbing	380.00		
Plastering	253.00	Total	$4,422.00

Built in 1902. Oak Wainscoting and Ceiling in Dining Room; Oak Finish in Stair Hall and All M Rooms on First Floor; Cypress in Balance of House. For Exterior, See Page 221.



SECOND-FLOOR PLAN OF RESIDENCE FOR MR. HANS HOFFMAN, MILWAUKEE, WIS.

First-Floor Plan Shown on Opposite Page.

practice, the number of risers in the well-hole will determine this height.

Now, from point n, draw a few treads and risers as shown; and along the nosing of the steps, draw the pitch-line; continue this line over the tangents d'', c'', and m, down to where it connects with the bottom level tangent, as shown. This gives the pitch or inclination to the tangents over and above the well-hole. The same line is shown in Fig. 93, folded around the well-hole, from n, where it connects with the flight at the upper end of the well-hole, to a, where it connects with the level-landing rail at the bottom of the well-hole. It will be observed that the upper portion, from joint n to joint h, over the tangents c'' and d'', coincides with the pitch-line of the same tangents as presented in Fig. 92, where they are used to find the true angle between the tangents as it is required on the face-mould to square the joints of the wreath at h.

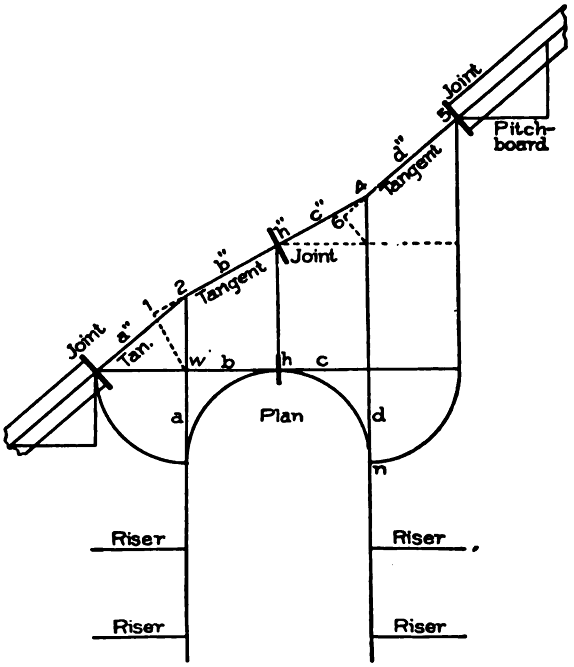


Fig. 95. Well-Hole Connecting Two Flights, with Two Wreath-Pieces, Each Containing Portions of Unequal Pitch.

In Fig. 89 the same pitch is shown given to tangent m as in Fig. 94; and in both figures the pitch is shown to be the same as that over and above the upper connecting tangents c'' and d'', which is a necessary condition where a joint, as shown at h in Figs. 93 and 94, is to connect two pieces of wreath as in this example.

In Fig. 94 are shown the two face-moulds for the wreaths, placed upon the pitch-line of the tangents over the well-hole. The angles between the tangents of the face-moulds have been found in this figure by the same method as in Figs. 89 and 92, which, if compared with the present figure, will be found to correspond, excepting only the curves of the face-moulds in Fig. 94.

The foregoing explanation of the tangents will give the student a fairly good idea of the use made of tangents in wreath construction. The treatment, however, would not be complete if left off at this point, as it shows how to handle tangents under only two conditions—namely, first, when one tangent inclines and the other is level, as at *a* and *m;* second, when both tangents incline, as shown at c'' and d''.

In Fig. 95 is shown a well-hole connecting two flights, where two portions of unequal pitch occur in both pieces of wreath. The first piece over the tangents *a* and *b* is shown to extend from the square end of the straight rail of the bottom flight, to the joint in the center of the well-hole, the bottom tangent a'' in this wreath inclining more than the upper tangent b''. The other piece of wreath is shown to connect with the bottom one at the joint h'' in the center of the well-hole, and to extend over tangents c'' and d'' to connect with the rail of the upper flight. The relative inclination of the two tangents in this wreath, is the reverse of that of the two tangents of the lower wreath. In the lower piece, the bottom tangent a'', as previously stated, inclines considerably more than does the upper tangent b''; while in the upper piece, the bottom tangent c'' inclines considerably less than the upper tangent d''.

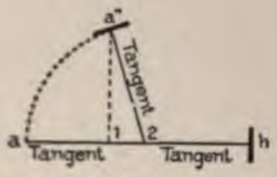


Fig. 96. Finding Angle between Tangents for Bottom Wreath of Fig. 95.

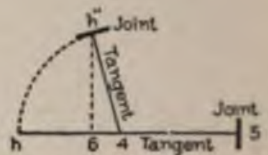


Fig. 97. Finding Angle between Tangents for Upper Wreath of Fig. 95.

The question may arise: What causes this? Is it for variation in the inclination of the tangents over the well-hole? It is simply owing to the tangents being used in handrailing to square the joints.

The inclination of the bottom tangent a'' of the bottom wreath is clearly shown in the diagram to be determined by the inclination of the bottom flight. The joint at a'' is made square to both the straight rail of the flight and to the bottom tangent of the wreath; the rail and tangent, therefore, must be equally inclined, otherwise the joint will not be a true butt-joint. The same remarks apply to the joint at 5, where the upper wreath is shown jointed to the straight rail of the upper flight. In this case, tangent d'' must be fixed to incline conformably to the inclination of the upper rail; otherwise the joint at 5 will not be a true butt-joint.

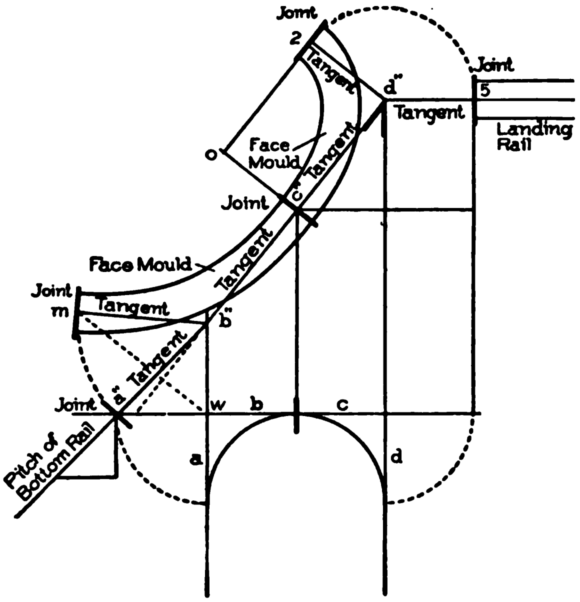


Fig. 98. Diagram of Tangents and Face-Mould for Sta'r with Well-Hole at Upper Landing.

The same principle is applied in determining the pitch or inclination over the crown tangents b'' and c''. Owing to the necessity of jointing the two wreaths, as shown at *h*, these two tangents must have the same inclination, and therefore must be fixed, as shown from 2 to 4, over the crown of the well-hole.

The tangents as here presented are those of the elevation, not of the face-mould. Tangent a'' is the elevation of the side plan tangent a; tangents b'' and c'' are shown to be the elevations of the plan tangents b and c; so, also, is the tangent d'' the elevation of the side plan tangent d.

If this diagram were folded, as Fig. 94 was shown to be in Fig. 93, the tangents of the elevation—namely, a'', b'', c'', d''—would stand over and above the plan tangents a, b, c, d of the well-hole. In practical work, this diagram must be drawn full size. It gives the correct length to each tangent as required on the face-mould, and furnishes also the data for the lay-out of the mould.

Fig. 96 shows how to find the angle between the tangents of the face-mould for the bottom wreath, which, as shown in Fig. 95, is to span over the first plan quadrant *a b*. The elevation tangents *a″* and *b″*, as shown, will be the tangents of the mould. To find the angle between the tangents, draw the line *a h* in Fig. 96; and from *a*, measure to 2 the length of the bottom tangent *a″* in Fig. 95; the length from 2 to *h*, Fig 96, will equal the length of the upper tangent *b″*, Fig. 95.

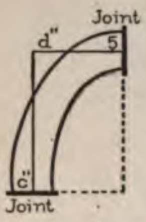


Fig. 99. Drawing Mould when One Tangent is Level and One Inclined over Right-Angled Plan.

From 2 to 1, measure a distance equal to 2-1 in Fig. 95, the latter being found by dropping a perpendicular from *w* to meet the tangent *b″* extended. Upon 1, erect a perpendicular line; and placing the dividers on 2, extend to *a;* turn over to the perpendicular at *a″*; connect this point with 2, and the line will be the bottom tangent as required on the face-mould. The upper tangent will be the line 2-*h*, and the angle between the two lines is shown at 2. Make the joint at *h* square to 2-*h*, and at *a″* square to *a″*-2.

The mould as it appears in Fig. 96 is complete, except the curve, which is comparatively a small matter to put on, as will be shown further on. The main thing is to find the angle between the tangents, which is shown at 2, to give them the direction to square the joints.

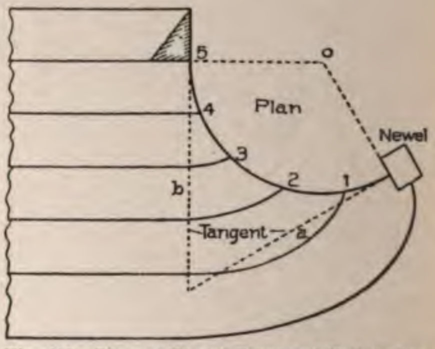


Fig. 100. Plan of Curved Steps and Stringer at Bottom of Stair.

In Fig. 97 is shown how to find the angle between the tangents *c″* and *d″* shown in Fig. 95, as required on the face-mould. On the line *h*–5, make *h*–4 equal to the length of the bottom tangent of the wreath, as shown at *h″*–4 in Fig. 95; and 4–5 equal to the length of the upper tangent *d″*. Measure from 4 the distance shown at 4–6 in Fig 95, and place it from 4 to 6 as shown in Fig. 97; upon 6 erect a perpendicular line. Now place the dividers on 4; extend to *h;* turn over to cut the perpendicular in *h″;* connect this point with 4, and the angle shown at 4 will be the angle required to square the joints of the wreath as shown at *h″* and 5, where the joint at 5 is shown drawn square to the line 4–5, and the joint at *h″* square to the line 4 *h″*.

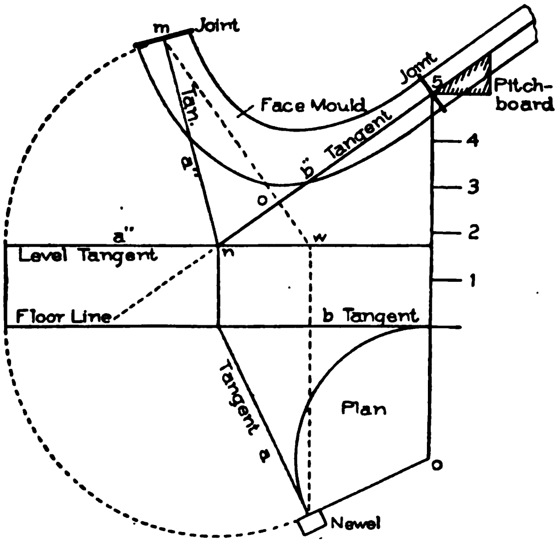


Fig. 101. Finding Angle between Tangents for Squaring Joints of Ramped Wreath.

Fig. 98 is a diagram of tangents and face-mould for a stairway having a well-hole at the top landing. The tangents in this example will be two equally inclined tangents for the bottom wreath; and for the top wreath, one inclined and one level, the latter aligning with the level rail of the landing.

The face-mould, as here presented, will further help toward an understanding of the layout of face-moulds as shown in Figs. 96 and 97. It will be observed that the pitch of the bottom rail is continued from *a″* to *b″*, a condition caused by the necessity of jointing the wreath to the end of the straight rail at *a″*, the joint being made square to both the straight rail and the bottom tangent *a″*. From *b″* a line is drawn to *d″*, which is a fixed point determined by the number of risers in the well-hole. From point *d″*, the level tangent *d″* 5 is drawn in line with the level rail of the landing; thus the pitch-line of the tangents over the well-hole is found, and, as was shown in the explanation of Fig. 95, the tangents as here presented will be those required on the face-mould to square the joints of the wreath.

In Fig. 98 the tangents of the face-mould for the bottom wreath are shown to be *a″* and *b″*. To place tangent *a″* in position on the face-mould, it is revolved, as shown by the arc, to *m,* cutting a line previously drawn from *w* square to the tangent b'' extended. Then, by connecting *m* to b'', the bottom tangent is placed in position on the face-mould. The joint at *m* is to be made square to it; and the joint at *c*, the other end of the mould, is to be made square to the tangent b''.

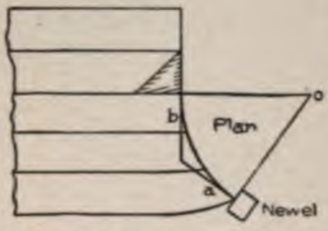


Fig. 102. Bottom Steps with Obtuse-Angle Plan.

The upper piece of wreath in this example is shown to have tangent c'' inclining, the inclination being the same as that of the upper tangent b'' of the bottom wreath, so that the joint at c'', when made square to both tangents, will butt square when put together. The tangent d'' is shown to be level, so that the joint at 5, when squared with it, will butt square with the square end of the level-landing rail. The level tangent is shown revolved to its position on the face-mould, as from 5 to 2. In this last position, it will be observed that its angle with the inclined tangent c'' is a right angle; and it should be remembered that in every similar case where one tangent inclines and one is level over a square-angle plan tangent, the angle between the two tangents will be a right angle on the face-mould. A knowledge of this principle will enable the student to draw the mould for this wreath, as shown in Fig. 99, by merely drawing two lines perpendicular to each other, as d'' 5 and d'' c'', equal respectively to the level tangent d'' 5 and the inclined tangent c'' in Fig. 98. The joint at 5 is to be made square to d'' 5; and that at c'', to d'' c''. Comparing this figure with the face-mould as shown for the upper wreath in Fig. 98, it will be observed that both are alike.

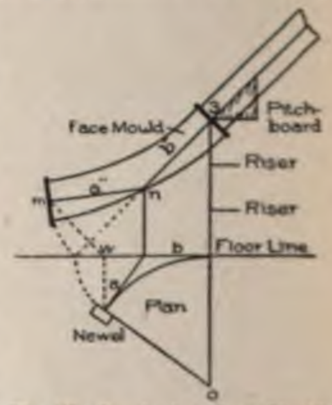


Fig. 103. Developing Face-Mould. Obtuse-Angle Plan.

In practical work the stair-builder is often called upon to deal with cases in which the conditions of tangents differ from all the examples thus far given. An instance of this sort is shown in Fig. 100, in which the angles between the tangents on the plan are acute.

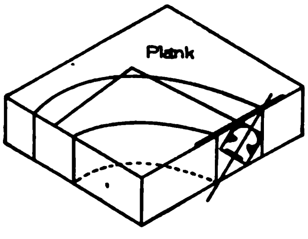


Fig. 104. Cutting Wreath from Plank.

In all the preceding examples, the tangents on the plan were at right angles; that is, they were square to one another.

Fig. 100 is a plan of a few curved steps placed at the bottom of a stairway with a curved stringer, which is struck from a center *o*. The plan tangents *a* and *b* are shown to form an acute angle with each other. The rail above a plan of this design is usually ramped at the bottom end, where it intersects the newel post, and, when so treated, the bottom tangent *a* will have to be level.

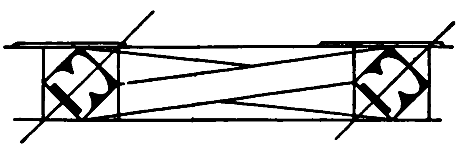


Fig. 105. Wreath Twisted, Ready to be Moulded.

In Fig. 101 is shown how to find the angle between the tangents on the face-mould that gives them the correct direction for squaring the joints of the wreath when it is determined to have it ramped. This figure must be drawn full size. Usually an ordinary drawing-board will answer the purpose. Upon the board, reproduce the plan of the tangents and curve of the center line of rail as shown in Fig. 100. Measure the height of 5 risers, as shown in Fig. 101, from the floor line to 5; and draw the pitch of the flight adjoining the wreath, from 5 to the floor line. From the newel, draw the dotted line to *w*, square to the floor line; from *w*, draw the line *w m*, square to the pitch-line b''. Now take the length of the bottom level tangent on a trammel, or on dividers if large enough, and extend it from *n* to *m*, cutting the line drawn previously from

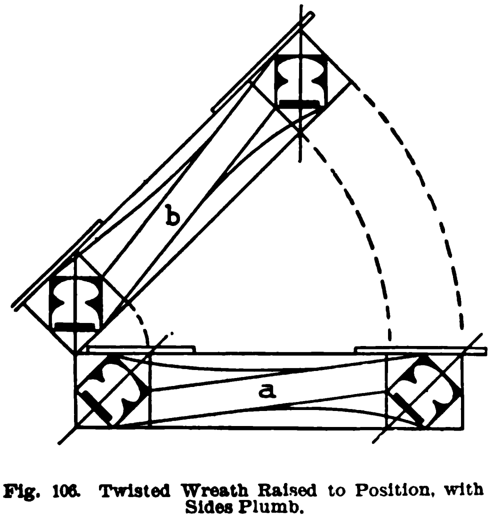


Fig. 106. Twisted Wreath Raised to Position, with Sides Plumb.

w, at *m*. Connect *m* to *n* as shown by the line *a″*. The intersection of this line with *b″* determines the angle between the two tangents *a″* and *b″* of the face-mould, which gives them the correct direction as required on the face-mould for squaring the joints. The joint at *m* is made square to tangent *a″*; and the joint at 5, to tangent *b″*.

In Fig. 102 is presented an example of a few steps at the bottom of a stairway in which the tangents of the plan form an obtuse angle with each other. The curve of the central line of the rail in this case will be less than a quadrant, and, as shown, is struck from the center *o*, the curve covering the three first steps from the newel to the springing.

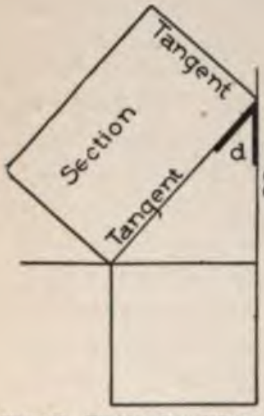


Fig. 107. Finding Bevel, Bottom Tangent Inclined, Top One Level.

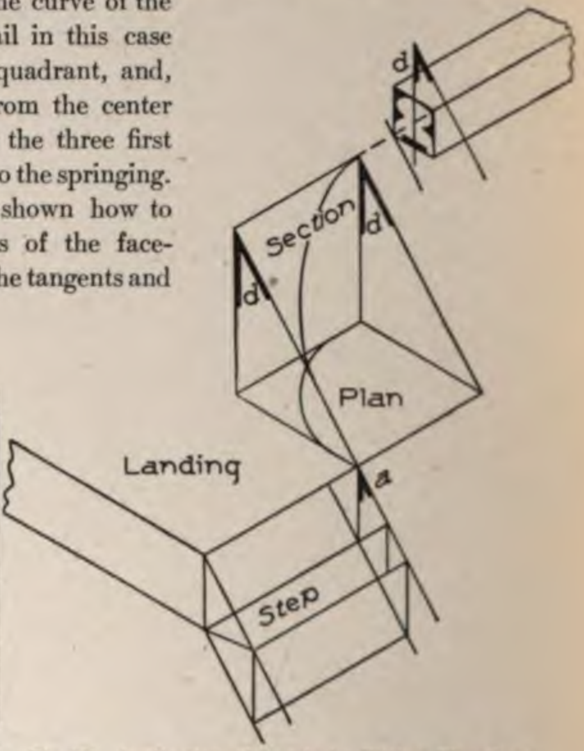


Fig. 108. Application of Bevels in Fitting Wreath to Rail.

In Fig. 103 is shown how to develop the tangents of the face-mould. Reproduce the tangents and curve of the plan in full size. Fix point 3 at a height equal to 3 risers from the floor line; at this point place the pitch-board of the flight to determine the pitch over the curve as shown from 3 through *b″* to the floor line. From the newel, draw a line to *w*, square to the floor line; and from *w*, square to the pitch-line *b″*, draw the line *w m*; connect *m* to *n*. This last line is the development of the bottom plan tangent *a*; and the line *b″* is the development of the plan tangent *b;* and the angle between the two lines *a″* and *b″* will give each line its true direction as required on the face-mould for squaring the joints of the wreath, as shown at *m* to connect square with the newel, and at 3 to connect square to the rail of the connecting flight.

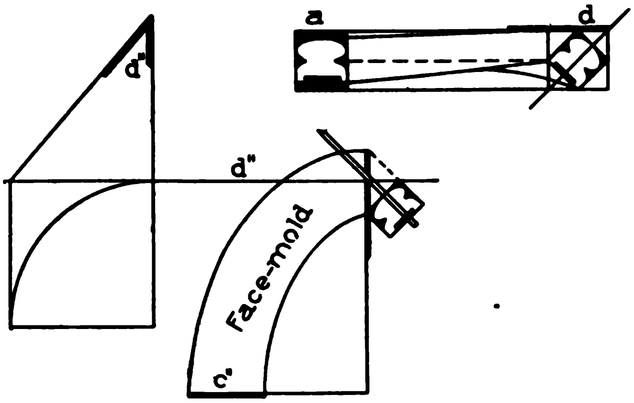


Fig. 109. Face-Mould and Bevel for Wreath, Bottom Tangent Level, Top One Inclined.

The wreath in this example follows the nosing line of the steps without being ramped as it was in the examples shown in Figs. 100 and 101. In those figures the bottom tangent *a* was level, while in Fig. 103 it inclines equal to the pitch of the upper tangent *b″* and of the flight adjoining. In other words, the method shown in Fig. 101 is applied to a construction in which the wreath is ramped; while in Fig. 103 the method is applicable to a wreath following the nosing line all along the curve to the newel.

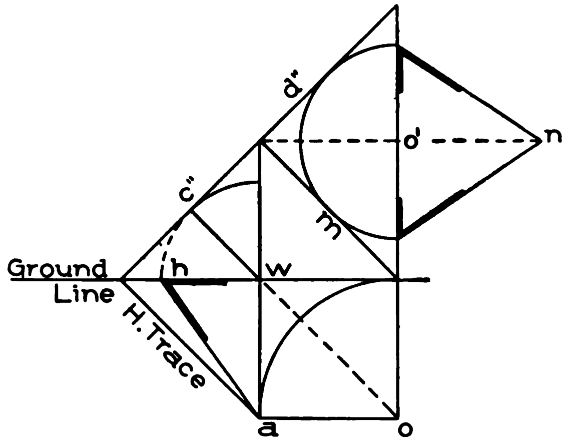


Fig. 110. Finding Bevels for Wreath with Two Equally Inclined Tangents.

The stair-builder is supposed to know how to construct a wreath under both conditions, as the conditions are usually determined by the Architect.

The foregoing examples cover all conditions of tangents that are likely to turn up in practice, and, if clearly understood, will enable the student to lay out the face-moulds for all kinds of curves.

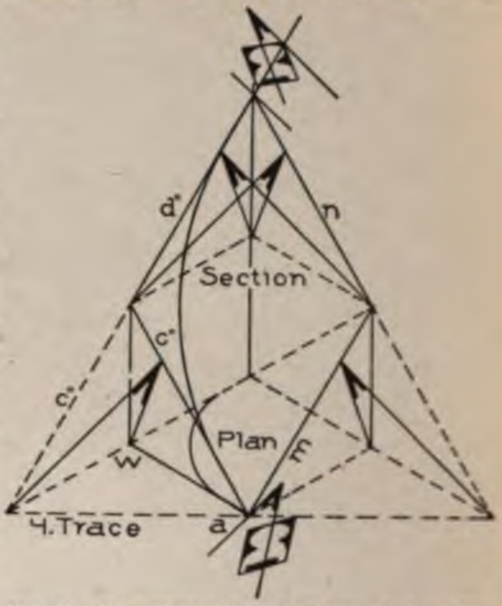


Fig. 111. Application of Bevels to Wreath Ascending on Plane Inclined Equally in Two Directions.

Bevels to Square the Wreaths. The next process in the construction of a wreath that the handrailer will be called upon to perform, is to find the bevels that will, by being applied to each end of it, give the correct angle to *square* or *twist* it when winding around the well-hole from one flight to another flight, or from a flight to a landing, as the case may be.

The wreath is first cut from the plank square to its surface as shown in Fig. 104. After the application of the bevels, it is twisted, as shown in Fig. 105, ready to be moulded; and when in position, ascending from one end of the curve to the other end, over the inclined plane of the section around the well-hole, its sides will be plumb, as shown in Fig. 106 at *b*. In this figure, as also in Fig. 105, the wreath *a* lies in a horizontal position in which its sides appear to be out of plumb as much as the bevels

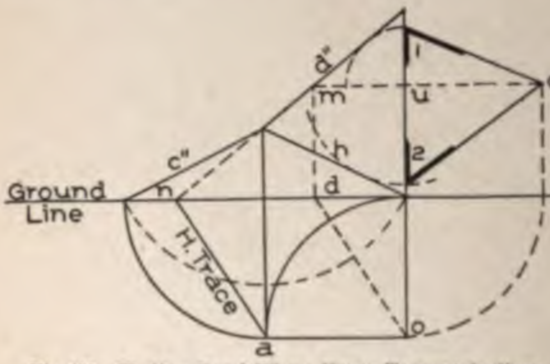


Fig. 112. Finding Bevel Where Upper Tangent Inclines More Than Lower One.

are out of plumb. In the upper part of the figure, the wreath *b* is shown placed in its position upon the plane of the section, where its sides are seen to be plumb. It is evident, as shown in the relative position of the wreath in this figure, that, if the bevel is the correct angle of the plane of the section whereon the wreath *b* rests in its ascent over the well-hole, the wreath will in that case have its sides plumb all along when in position. It is for this purpose that the bevels are needed.

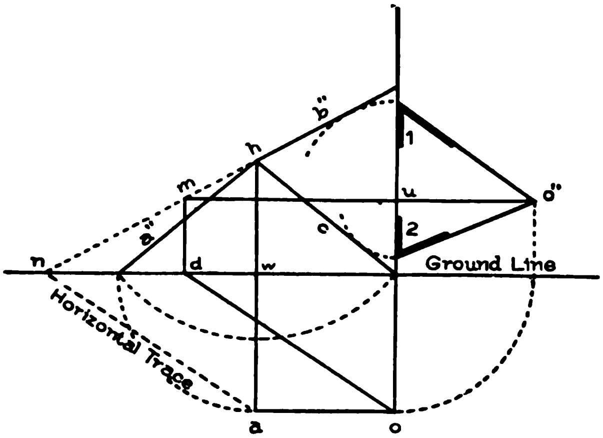


Fig. 113. Finding Bevel Where Upper Tangent Inclines Less Than Lower One.

A method of finding the bevels for *all wreaths* (which is considered rather difficult) will now be explained:

First Case. In Fig. 107 is shown a case where the bottom tangent of a wreath is inclining, and the top one level, similar to the top wreath shown in Fig. 98. It has already been noted that the plane of the section for this kind of wreath inclines to one side only; therefore one bevel only will be required to square it, which is shown at *d*, Fig. 107. A view of this plane is given in Fig. 108; and the bevel *d*, as there shown, indicates the angle of the inclination, which also is the bevel required to square the end *d* of the wreath. The bevel is shown applied to the end of the landing rail in exactly the same manner in which it is to be applied to the end of the wreath. The true bevel for this wreath is found at the upper angle of the pitch-board. At the end *a*, as already stated, no bevel is required, owing to the plane inclining in one direction only. Fig. 109 shows a face-mould and bevel for a wreath with the bottom tangent level and the top tangent inclining, such as the piece at the bottom connecting with the landing rail in Fig. 94.

Second Case. It may be required to find the bevels for a wreath having two equally inclined tangents. An example of this kind also is shown in Fig. 94, where both the tangents c'' and d'' of the upper wreath incline equally. Two bevels are required in this case, because the plane of the section is inclined in two directions; but, owing to the inclinations being alike, it follows that the two will be the same. They are to be applied to both ends of the wreath, and, as shown in Fig. 105, in the same direction—namely, toward the inside of the wreath for the bottom end, and toward the outside for the upper end.

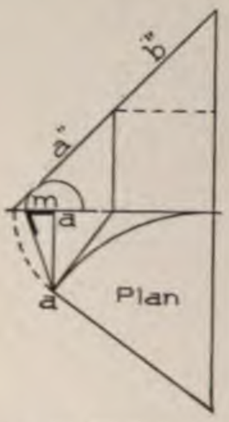


Fig. 114. Finding Bevel Where Tangents Incline Equally over Obtuse-Angle Plan.

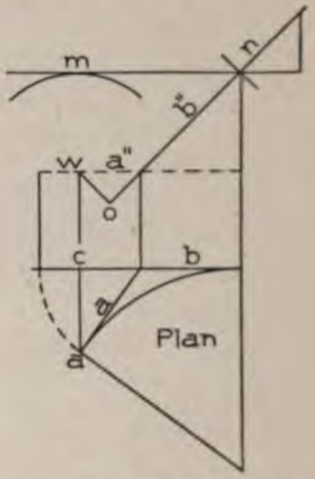


Fig. 115. Same Plan as in Fig. 114, but with Bottom Tangent Level.

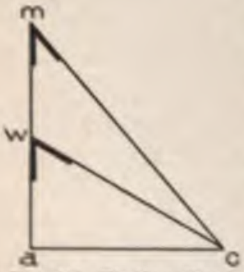


Fig. 116. Finding Bevels for Wreath of Fig. 115.

In Fig. 110 the method of finding the bevels is shown. A line is drawn from w to c'', square to the pitch of the tangents, and turned over to the ground line at h, which point is connected to a as shown. The bevel is at h. To show that equal tangents have equal bevels, the line m is drawn, having the same inclination as the bottom tangent c'', but in another direction. Place the dividers on o', and turn to touch the lines d'' and m, as shown by the semicircle. The line from o' to n is equal to the side plan tangent *w a*, and both the bevels here shown are equal to the one already found. They represent the angle of inclination of the plane whereon the wreath ascends, a view of which is given in Fig. 111, where the plane is shown to incline equally in two directions. At both ends is shown a section of a rail; and the bevels are applied to show how, by means of them, the wreath is *squared* or *twisted* when winding around the well-hole and ascending upon the plane of the section. The view given in this figure will enable the student to understand the nature of the bevels found in Fig. 110 for a wreath having two equally inclined tangents; also for all other wreaths of equally inclined tangents, in that every wreath in such case is assumed to rest upon an inclined plane in its ascent over the well-hole, the bevel in every case being the angle of the inclined plane.

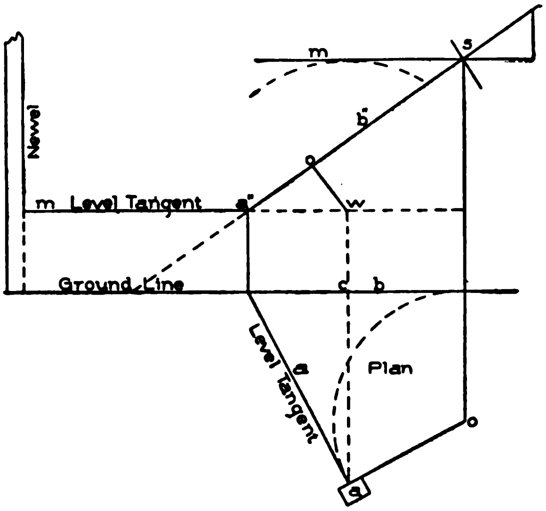


Fig. 117. Upper Tangent Inclined, Lower Tangent Level, Over Acute-Angle Plan.

Third Case. In this example, two unequal tangents are given, the upper tangent inclining more than the bottom one. The method shown in Fig. 110 to find the bevels for a wreath with two equal tangents, is applicable to all conditions of variation in the inclination of the tangents. In Fig. 112 is shown a case where the upper tangent *d″* inclines more than the bottom one *c″*. The method in all cases is to continue the line of the upper tangent *d″*, Fig. 112, to the ground line as shown at *n;* from *n,* draw a line to *a,* which will be the horizontal trace of the plane. Now, from *o,* draw a line parallel to *a n,* as shown from *o* to *d,* upon *d,* erect a perpendicular line to cut the tangent *d″*, as shown, at *m;* and draw the line *m u o″*. Make *u o″* equal to the length of the plan tangent as shown by the arc from *o*. Put one leg of the dividers on *u;* extend to touch the upper tangent *d″*, and turn over to 1; connect 1 to *o″;* the bevel at 1 is to be applied to tangent *d″*. Again place the dividers on *u;* extend to the line *h*, and turn over to 2 as shown; connect 2 to *o″*, and the bevel shown at 2 will be the one to apply to the bottom tangent *c″*. It will be observed that the line *h* represents the bottom tangent. It is the same length and has the same inclination. An example of this kind of wreath was shown in Fig. 95, where the upper tangent *d″* is shown to incline more than the bottom tangent *c″* in the top piece extending from *h″* to 5. Bevel 1, found in Fig. 112, is the real bevel for the end 5; and bevel 2, for the end *h″* of the wreath shown from *h″* to 5 in Fig. 95.

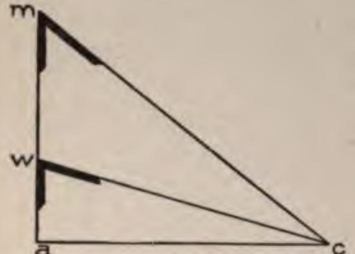


Fig. 118. Finding Bevels for Wreath of Plan, Fig. 117.

Fourth Case. In Fig. 113 is shown how to find the bevels for a wreath when the upper tangent inclines less than the bottom tangent. This example is the reverse of the preceding one; it is the condition of tangents found in the bottom piece of wreath shown in Fig. 95. To find the bevel, continue the upper tangent *b″* to the ground line, as shown at *n;* connect *n* to *a*, which will be the horizontal trace of the plane. From *o*, draw a line parallel to *n a*, as shown from *o* to *d;* upon *d*, erect a perpendicular line to cut the continued portion of the upper tangent *b″* in *m;* from *m*, draw the line *m u o″* across as shown. Now place the dividers on *u;* extend to touch the upper tangent, and turn over to 1; connect 1 to *o″;* the bevel at 1 will be the one to apply to the tangent *b″* at *h*, where the two wreaths are shown connected in Fig. 95. Again place the dividers on *u;* extend to touch the line *c;* turn over to 2; connect 2 to *o″;* the bevel at 2 is to be applied to the bottom tangent *a″* at the joint where it is shown to connect with the rail of the flight.

Fifth Case. In this case we have two equally inclined tangents over an obtuse-angle plan. In Fig. 102 is shown a plan of this kind; and in Fig. 103, the development of the face-mould.

In Fig. 114 is shown how to find the bevel. From *a*, draw a line to *a′*, square to the ground line. Place the dividers on *a′;* extend to touch the pitch of tangents, and turn over as shown to *m;* connect *m* to *a*. The bevel at *m* will be the only one required for this wreath, but it will have to be applied to both ends, owing to the two tangents being inclined.

Sixth Case. In this case we have one tangent inclining and one tangent level, over an acute-angle plan.

In Fig. 115 is shown the same plan as in Fig. 114; but in this case the bottom tangent a'' is to be a level tangent. Probably this condition is the most commonly met with in wreath construction at the present time. A small curve is considered to add to the appearance of the stair and rail; and consequently it has become almost a "fad" to have a little curve or stretch-out at the bottom of the stairway, and in most cases the rail is ramped to intersect the newel at right angles instead of at the pitch of the flight. In such a case, the bottom tangent a'' will have to be a level tangent, as shown at a'' in Fig. 115, the pitch of the flight being over the plan tangent *b* only.

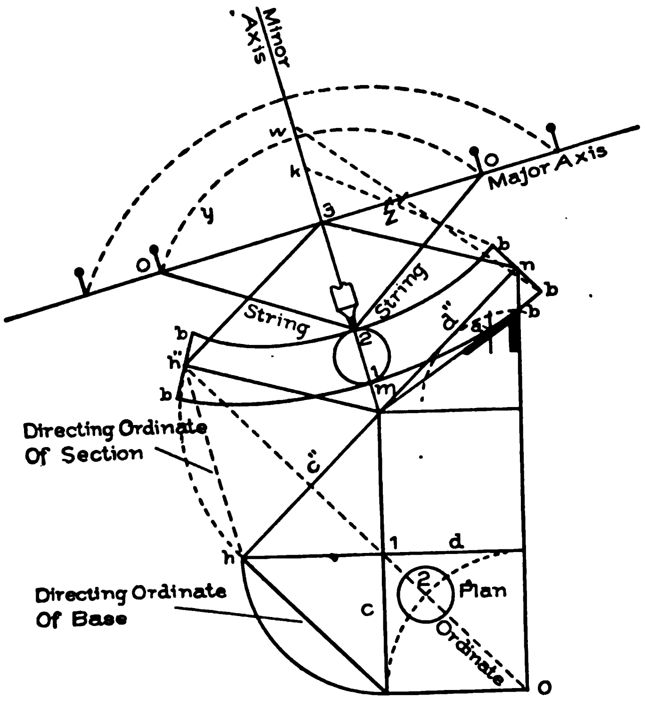


Fig. 119. Laying Out Curves on Face-Mould with Pins and String.

To find the bevels when tangent b'' inclines and tangent a'' is level, make *a c* in Fig. 116 equal to *a c* in Fig. 115. This line will be the base of the two bevels. Upon *a*, erect the line *a w m* at right angles to *a c;* make *a w* equal to *o w* in Fig. 115; connect *w* and *c;* the bevel at *w* will be the one to apply to tangent b'' at *n* where the wreath is joined to the rail of the flight. Again, make *a m* in Fig. 116 equal the distance shown in Fig. 115 between *w* and *m*, which is the full height over which tangent b'' is inclined; connect *m* to *c* in Fig. 116, and at *m* is the bevel to be applied to the level tangent a''.

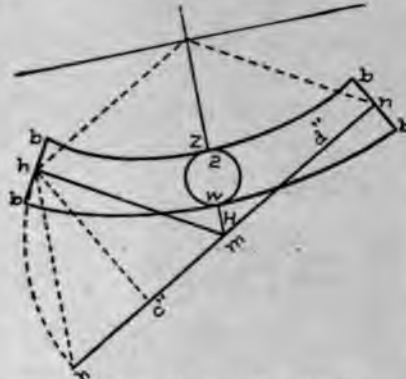


Fig. 120. Simple Method of Drawing Curves on Face-Mould.

Seventh Case. In this case, illustrated in Fig. 117, the upper tangent b'' is shown to incline, and the bottom tangent a'' to be level, over an acute-angle plan. The plan here is the same as that in Fig. 100, where a curve is shown to stretch out from the line of the straight stringer at the bottom of a flight to a newel, and is large enough to contain five treads, which are gracefully rounded to cut the curve of the central line of rail in 1, 2, 3, 4. This curve also may be used to connect a landing rail to a

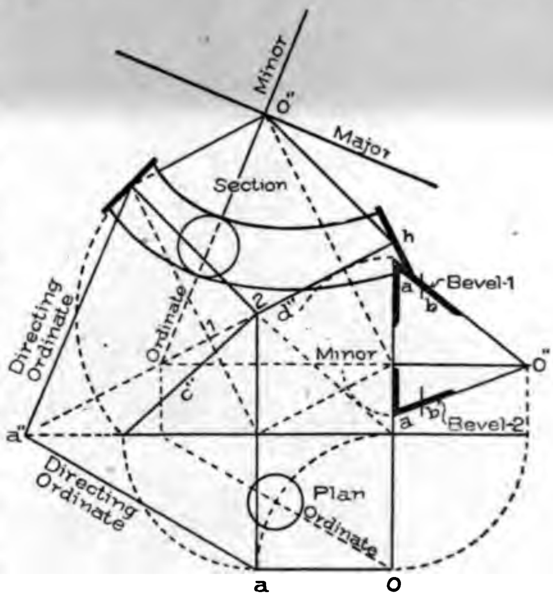


Fig. 121. Tangents, Bevels, Mould-Curves, etc., from Bottom Wreath of Fig. 95, in which Upper Tangent Inclines Less than Lower One.

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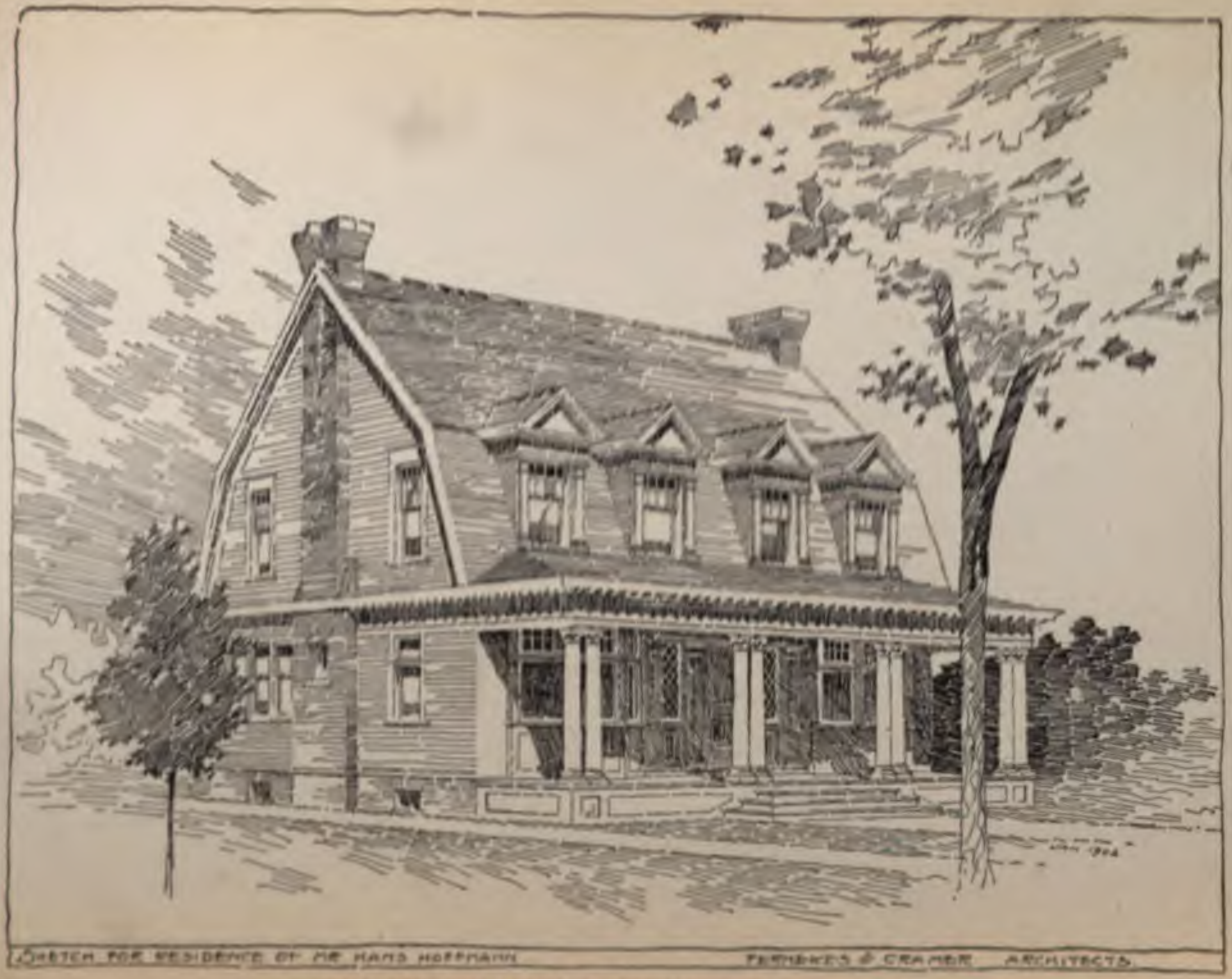

SKETCH FOR RESIDENCE OF MR HANS HOFFMANN
FERNEKES & CRAMER ARCHITECTS

RESIDENCE FOR MR. HANS HOFFMAN, MILWAUKEE, WIS.

Fernekes & Cramer, Architects

flight, either at top or bottom, when the plan is acute-angled, as will be shown further on.

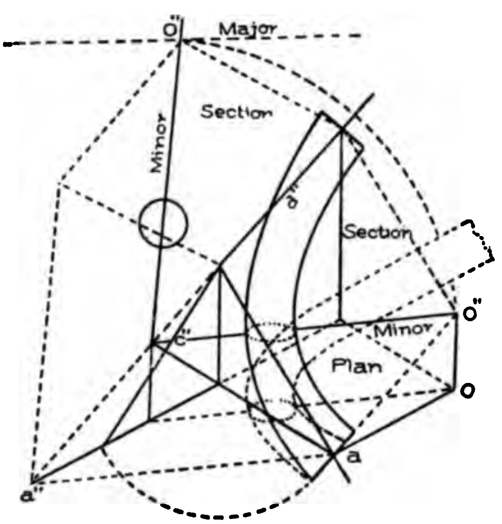


Fig. 122. Developed Section of Plane Inclining Unequally in Two Directions.

To find the bevels—for there will be two bevels necessary for this wreath, owing to one tangent *b''* being inclined and the other tangent *a''* being level—make *a c*, Fig. 118, equal to *a c* in Fig. 117, which is a line drawn square to the ground line from the newel and shown in all preceding figures to have been used for the base of a triangle containing the bevel. Make *a w* in Fig. 118 equal to *w o* in Fig. 117, which is a line drawn square to the inclined tangent *b''* from *w;* connect *w* and *c* in Fig. 118. The bevel shown at *w* will be the one to be applied to the joint 5 on tangent *b''*, Fig. 117. Again, make *a m* in Fig. 118 equal to the distance shown in Fig. 117 between the line representing the level tangent and the line *m'* 5, which is the height that

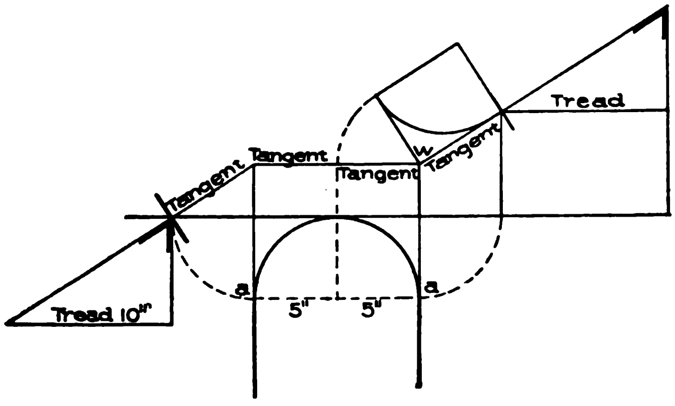


Fig 123. Arranging Risers around Well-Hole on Level-Landing Stair, with Radius of Central Line of Rail One-Half Width of Tread.

tangent b'' is shown to rise; connect *m* to *c* in Fig. 118; the bevel shown at *m* is to be applied to the end that intersects with the newel as shown at *m* in Fig. 117.

The wreath is shown developed in Fig. 101 for this case; so that, with Fig. 100 for plan, Fig. 101 for the development of the wreath, and Figs. 117 and 118 for finding the bevels, the method of handling any similar case in practical work can be found.

How to Put the Curves on the Face-Mould. It has been shown how to find the angle between the tangents of the face-mould, and that the angle is for the purpose of squaring the joints at the ends of the wreath. In Fig. 119 is shown how to lay out the curves by means of pins and a string—a very common practice among stair-builders. In this example the face-mould has equal tangents as shown at c'' and d''. The angle between the two tangents is shown at *m* as it will be required on the face-mould. In this figure a line is drawn from *m* parallel to the line drawn from *h*, which is marked in the diagram as "Directing Ordinate of Section." The line drawn from *m* will contain the minor axes; and a line drawn through the corner of the section at 3 will contain the major axes of the ellipses that will constitute the curves of the mould.

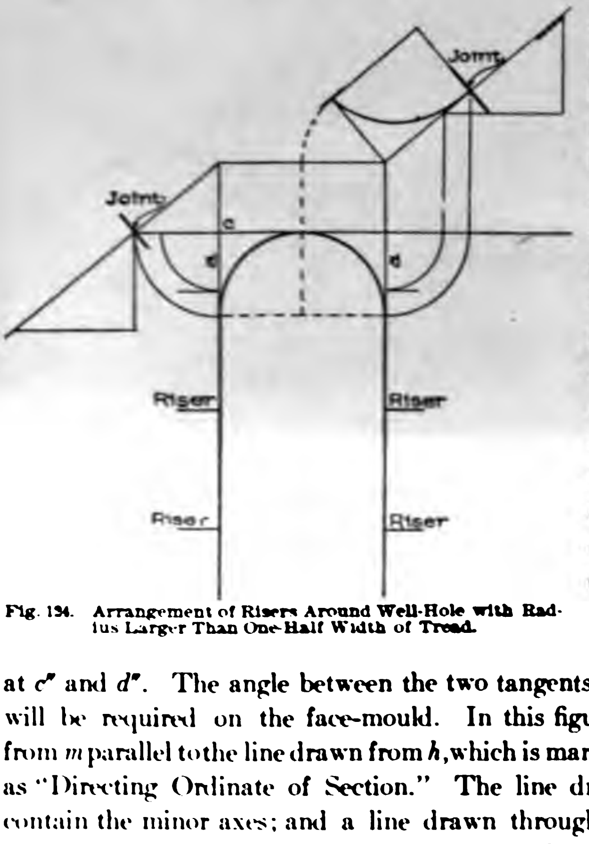


Fig. 134. Arrangement of Risers Around Well-Hole with Radius Larger Than One-Half Width of Tread.

The *major* is to be drawn square to the *minor*, as shown. Place, from point 3, the circle shown on the minor, at the same distance as the circle in the plan is fixed from the point *o*. The diameter of this circle indicates the width of the curve at this point. The width at each end is determined by the bevels. The distance *a b*, as shown upon the long edge of the bevel, is equal to ½ the width of the mould, and is the hypotenuse of a right-angled triangle whose base is ½ the width of the rail. By placing this dimension on each side of *n*, as shown at *b* and *b*, and on each side of *h″* on the other end of the mould, as shown also at *b* and *b*, we obtain the points *b* 2 *b* on the inside of the curve, and

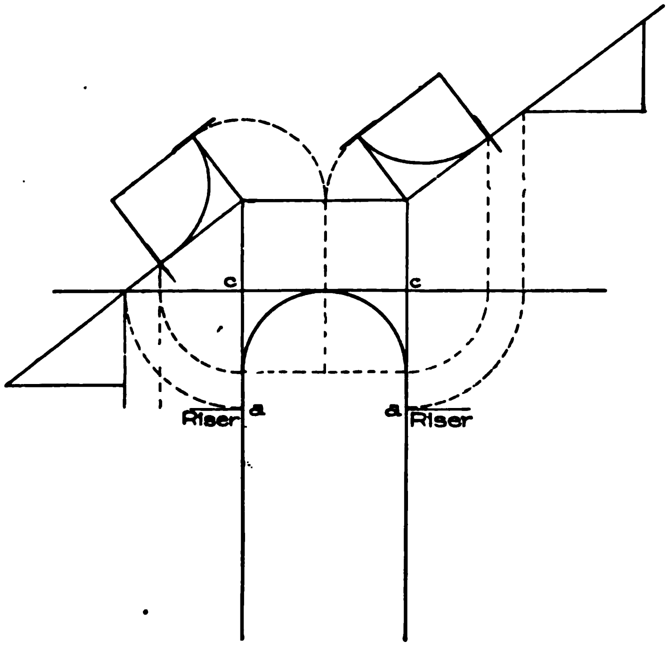


Fig. 125. Arrangement of Risers around Well-Hole, with Risers Spaced Full Width of Tread.

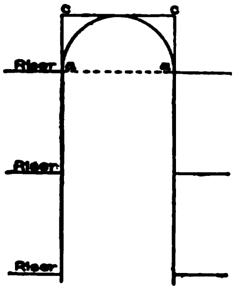


Fig. 126. Plan of Stair Shown in Fig. 123.

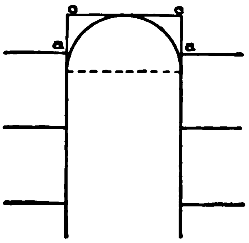


Fig. 127. Plan of Stair Shown in Fig. 124.

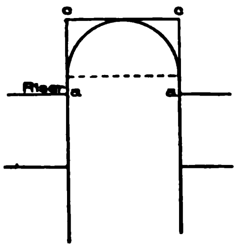


Fig. 128. Plan of Stair Shown in Fig. 125.

the points *b* 1 *b* on the outside. It will now be necessary to find the elliptical curves that will contain these points; and before this can be done, the exact length of the *minor* and *major* axes respectively must be determined. The length of the minor axis for the inside curve will be the distance shown from 3 to 2; and its length for the outside will be the distance shown from 3 to 1.

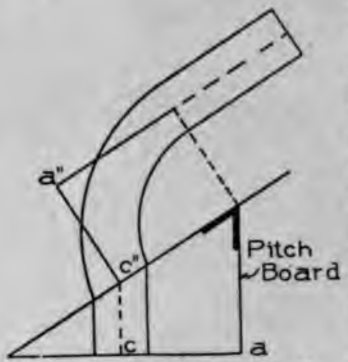


Fig. 129. Drawing Face-Mould for Wreath from Pitch-Board.

To find the length of the major axis for the inside, take the length of half the minor for the inside on the dividers: place one leg on *b*, extend to cut the major in *z*, continue to the minor as shown at *k*. The distance from *b* to *k* will be the length of the semi-major axis for the inside curve.

To draw the curve, the points or *foci* where the pins are to be fixed must be found on the major axis. To find these points, take the length of *b k* (which is, as previously found, the exact length of the semi-major for the inside curve) on the dividers; fix one leg at 2, and describe the arc *Y*, cutting the major where the pins are shown fixed, at *o* and *o*. Now take a piece of string long enough to form a

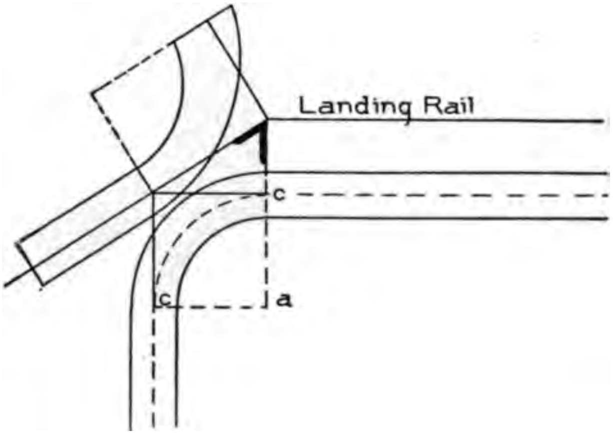


Fig. 130. Development of Face-Mould for Wreath Connecting Rail of Flight with Level-Landing Rail.

loop around the two and extending, when tight, to 2, where the pencil is placed; and, keeping the string tight, sweep the curve from *b* to *b*.

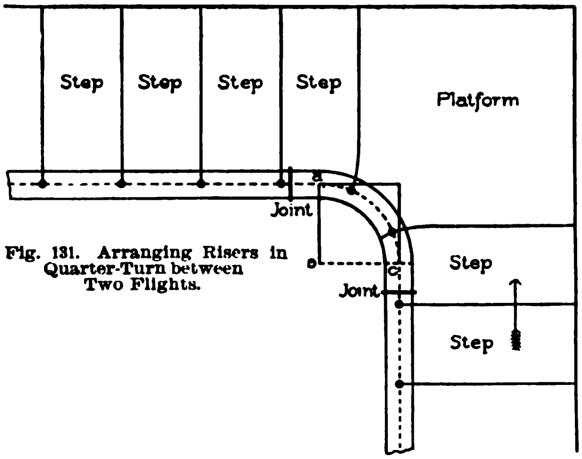


Fig. 131. Arranging Risers in Quarter-Turn between Two Flights.

The same method, for finding the *major* and *foci* for the outside curve, is shown in the diagram. The line drawn from *b* on the outside of the joint at *n*, to *w*, is the semi-major for the outside curve; and the points where the outside pins are shown on the major will be the *foci*.

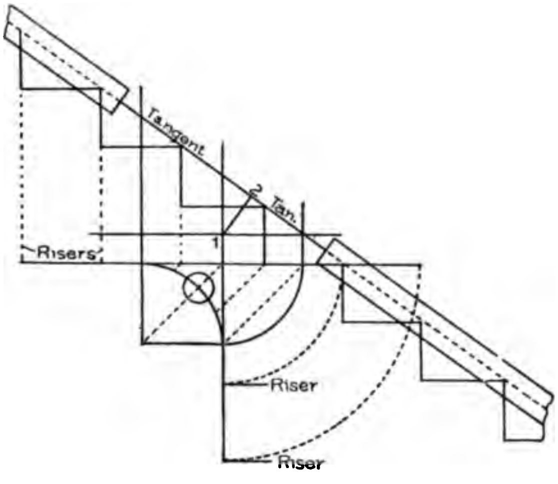


Fig. 132. Arrangement of Risers around Quarter-Turn Giving Tangents Equal Pitch with Connecting Flight.

To draw the curves of the mould according to this method, which tific one, may seem a complicated problem; but once it is d, it becomes very simple. A simpler way to draw them, however, is shown in Fig. 120.

inding Bevel
th of Plan.
. 122.

The width on the minor and at each end will have to be determined by the method just explained in connection with Fig. 119. In Fig 120, the points *b* at the ends, and the points in which the circumference of the circle cuts the minor axis, will be points contained in the curves, as already ow take a flexible lath; bend it to touch *b*, *z*, and *b* e, and *b*, *w*, and *b* for the outside curve. This met the curve is comparatively flat, as in the example own; but where the mould has a sharp curva-

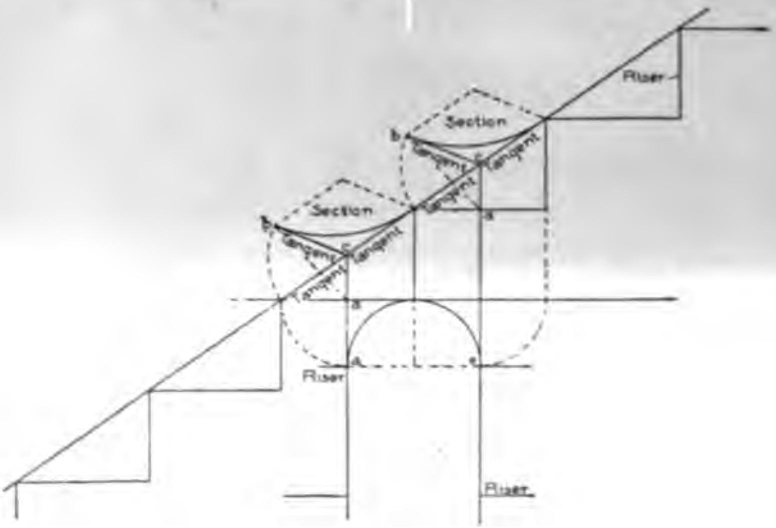


Fig. 134. Well-Hole with Riser in Center. Tangents of Face-Mould, and Central Line of Rail, Developed.

ture, as in case of the one shown in Fig. 101, the method shown in Fig. 119 must be adhered to.

With a clear knowledge of the above two methods, the student will be able to put curves on any mould.

The mould shown in these two diagrams, Figs. 119 and 120, is for the upper wreath, extending from *h* to *n* in Fig. 94 A practical handrailer would draw only what is shown in Fig. 120. He would take the lengths of tangents from Fig. 94, and place them as shown at *h m* and *m n*. By comparing Fig. 120 with the tangents of the upper wreath in Fig. 94, it will be easy for the student to understand the remaining lines shown in Fig. 120. The bevels are shown applied to the mould in Fig. 105, to give it the twist. In Fig. 106, is shown how, after the rail is twisted and placed in position over and above the quadrant *c d* in Fig. 94, its sides will be plumb.

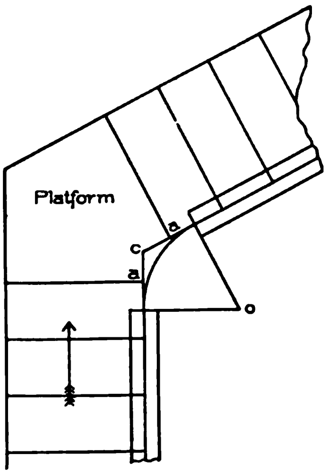


Fig. 135. Arrangement of Risers in Stair with Obtuse-Angle Plan.

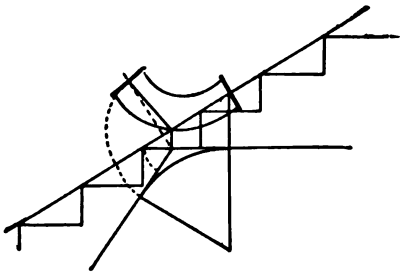


Fig. 136. Arrangement of Risers in Obtuse-Angle Plan, Giving Equal Pitch over Tangents and Flights. Face-Mould Developed.

In Fig. 121 are shown the tangents taken from the bottom wreath in Fig. 95 It was shown how to develop the section and find the angle for the tangents in the face-mould, in Fig. 113. The method shown in Fig. 119 for putting on the curves, would be the most suitable.

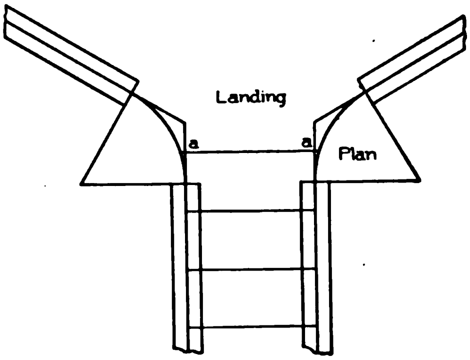


Fig. 137. Arrangement of Risers in Flight with Curve at Landing.

Fig. 121 is presented more for the purposes of study than as a method of construction. It contains all the lines made use of to find the developed section of a plane inclining unequally in two different directions, as shown in Fig. 122.

Arrangement of Risers in and around Well-Hole. An important matter in wreath construction is to have a knowledge of how to arrange the risers in and around a well-hole. A great deal of labor and material is saved through it; also a far better appearance to the finished rail may be secured.

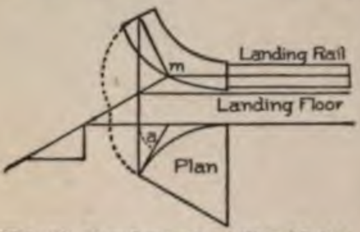


Fig. 138. Development of Face-Moulds for Plan, Fig. 137.

In level-landing stairways, the easiest example is the one shown in Fig. 123, in which the radius of the central line of rail is made equal to one-half the width of a tread. In the diagram the radius is shown to be 5 inches, and the treads 10 inches. The risers are placed in the springing, as at *a* and *a*. The elevation of the tangents by this arrangement will be, as shown, one level and one inclined, for each piece of wreath. When in this position, there is no trouble in finding the angle of the tangent as required on the face-mould, owing to that angle, as in every such case, being a right angle, as shown at *w*; also no special bevel will have to be found, because the upper bevel of the pitch-board contains the angle required.

The same results are obtained in the example shown in Fig. 124, in which the radius of the well-hole is larger than half the width of a tread, by placing the riser *a* at a distance from *c* equal to half the width of a tread, instead of at the springing as in the preceding example.

In Fig. 125 is shown a case where the risers are placed at a distance from *c* equal to a full tread, the effect in respect to the tangents of the face-mould and bevel being the same as in the two preceding examples. In Fig. 126 is shown the plan of Fig. 123; in Fig. 127, the plan of Fig. 124; and in Fig. 128, the plan of Fig. 125. For the wreaths shown in all these figures, there will be no necessity of *springing* the plank, which is a term used in handrailing to denote the twisting of the wreath; and no other bevel than the one at the upper end of the pitch-board will be required. This type of wreath, also, is the one that is required at the top of a landing when the rail of the flight intersects with a level-landing rail.

In Fig. 129 is shown a very simple method of drawing the face-mould for this wreath from the pitch-board. Make *a c* equal to the radius of the plan central line of rail as shown at the curve in Fig. 130. From where line *c c″* cuts the long side of the pitch-board, the line *c″ a″* is drawn at right angles to the long edge, and is made equal to the length of the plan tangent *a c*, Fig. 130. The curve is drawn by means of pins and string or a trammel.

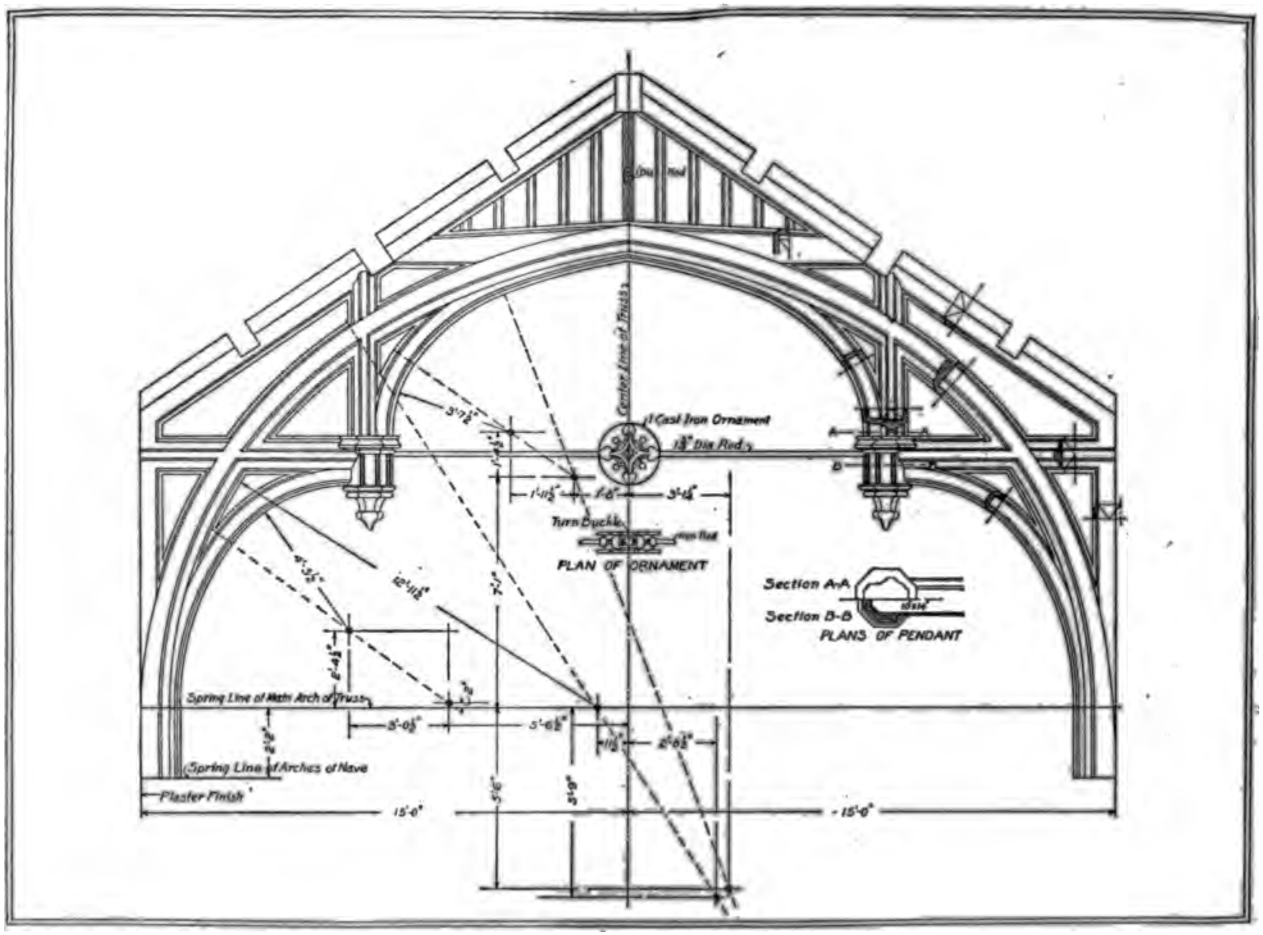
In Fig. 131 is shown a quarter-turn between two flights. The correct method of placing the risers in and around the curve, is to put the last one in the first flight one-half a step from springing *c*, and the first one in the second flight one-half a step from *a*, leaving a space in the curve equal to a full tread. By this arrangement, as shown in Fig. 132, the pitch-line of the tangents will equal the pitch of the connecting flight, thus securing the second easiest condition of tangents for the face-mould—namely, as shown, two equal tangents. For this wreath, only one bevel will be needed, and it is made up of the radius of the plan central line of the rail *o c*, Fig. 131, for base, and the line 1–2, Fig. 132, for altitude, as shown in Fig. 133.

The bevel shown in this figure has been previously explained in Figs. 105 and 106. It is to be applied to both ends of the wreath.

The example shown in Fig. 134 is of a well-hole having a riser in the center. If the radius of the plan central line of rail is made equal to one-half a tread, the pitch of tangents will be the same as of the flights adjoining, thus securing two equal tangents for the two sections of wreath. In this figure the tangents of the face-mould are developed, and also the central line of the rail, as shown over and above each quadrant and upon the pitch-line of tangents.

The same method may be employed in stairways having obtuse-angle and acute-angle plans, as shown in Fig. 135, in which two flights are placed at an obtuse angle to each other. If the risers shown at *a* and *a* are placed one-half a tread from *c*, this will produce in the elevation a pitch-line over the tangents equal to that over the flights adjoining, as shown in Fig. 136, in which also is shown the face-mould for the wreath that will span over the curve from one flight to another.

In Fig. 137 is shown a flight having the same curve at a landing. The same arrangement is adhered to respecting the placing of the risers, as shown at *a* and *a*. In Fig. 138 is shown how to develop the face-moulds.



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THE STEEL SQUARE

INTRODUCTORY

(Williams, Morris

The Standard Steel Square has a *blade* 24 inches long and 2 inches wide, and a *tongue* from 14 to 18 inches long and 1½ inches wide.

The blade is at right angles to the tongue.

The *face* of the square is shown in Fig. 1. It is always stamped with the manufacturer's name and number.

The reverse is the *back* (see Fig. 2).

The longer arm is the *blade;* the shorter arm, the *tongue.*

In the center of the tongue, on the face side, will be found two parallel lines divided into spaces (see Fig. 1); this is the *octagon scale.*

The spaces will be found numbered 10, 20, 30, 40, 50, 60, and 70, when the tongue is 18 inches long.

To draw an octagon of 8 inches square, draw a square 8 inches each way, and draw a perpendicular and a horizontal line through its center.

To find the length of the octagon side, place one point of a compass on any of the main divisions of the scale, and the other point of the compass on the eighth subdivision; then step this length off on each side of the center lines on the side of the square, which will give the points from which to draw the octagon lines.

The diameter of the octagon must equal in inches the number of spaces taken from the square.

On the opposite side of the tongue, in the center, will be found the *brace rule* (see Fig. 3). The fractions denote the *rise* and *run* of the brace, and the decimals the *length.* For example, a brace of 36 inches run and 36 inches rise, will have a length of 50.91 inches; a brace of 42 inches run and 42 inches rise, will have a length of 59.40 inches; etc.

On the back of the blade (Fig. 4) will be found the *board measure,* where eight parallel lines running along the length of the blade are shown and divided at every inch by cross-lines. Under 12, on the outer edge of the blade, will be found the various lengths of the boards, as 8, 9, 10, 11, 12, etc. For example, take a board 14 feet long and 9

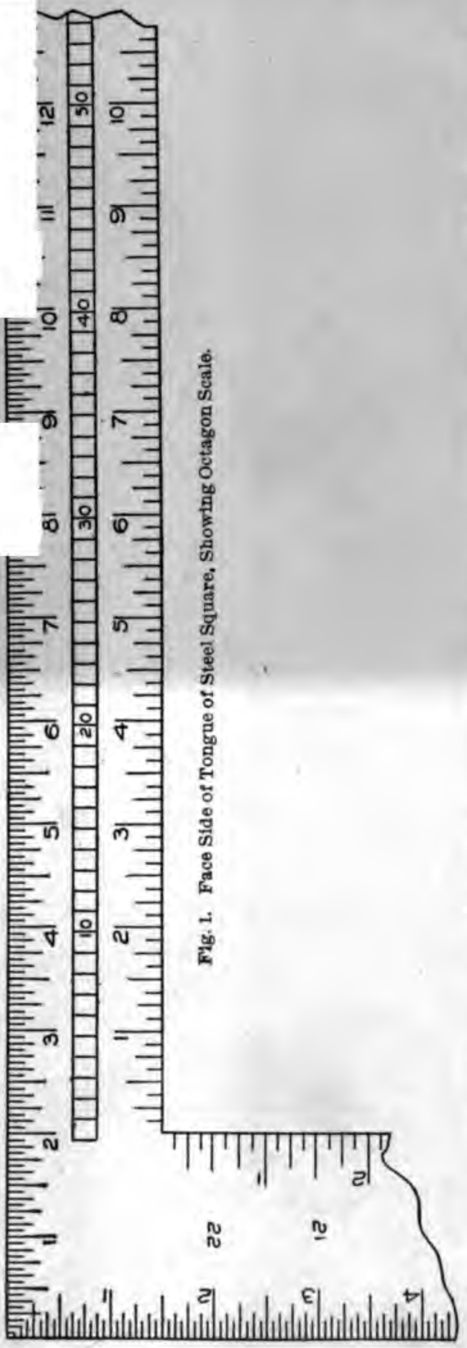


Fig. 1. Face Side of Tongue of Steel Square, Showing Octagon Scale.

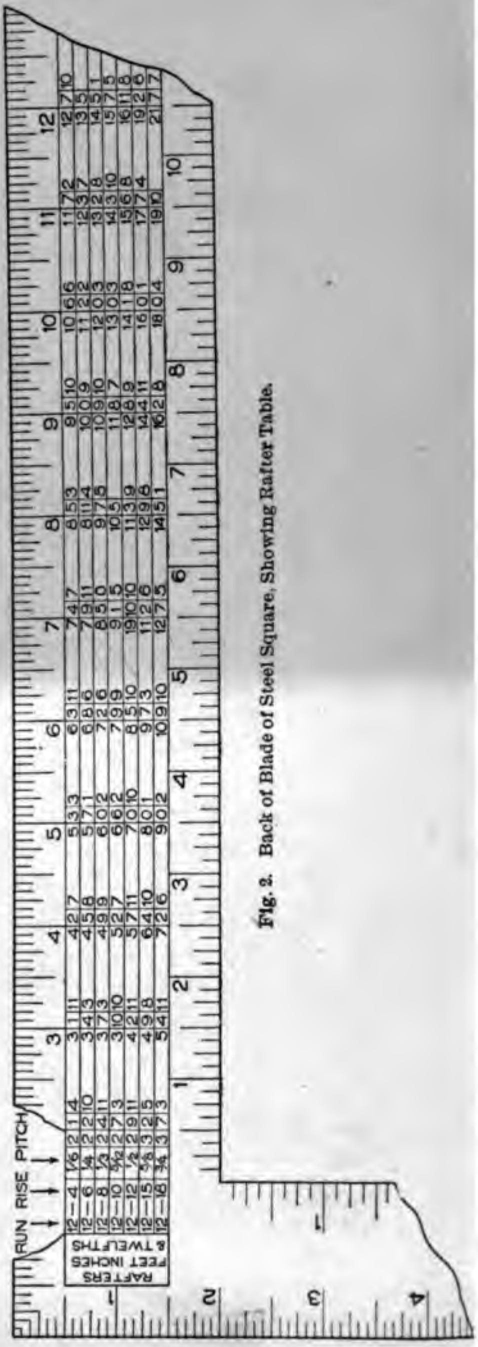


Fig. 2. Back of Blade of Steel Square, Showing Rafter Table.

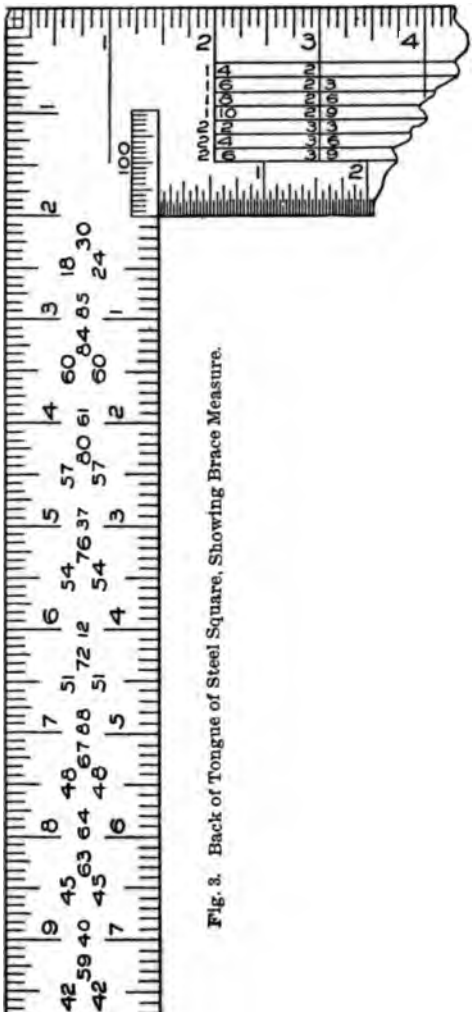


Fig. 3. Back of Tongue of Steel Square, Showing Brace Measure.

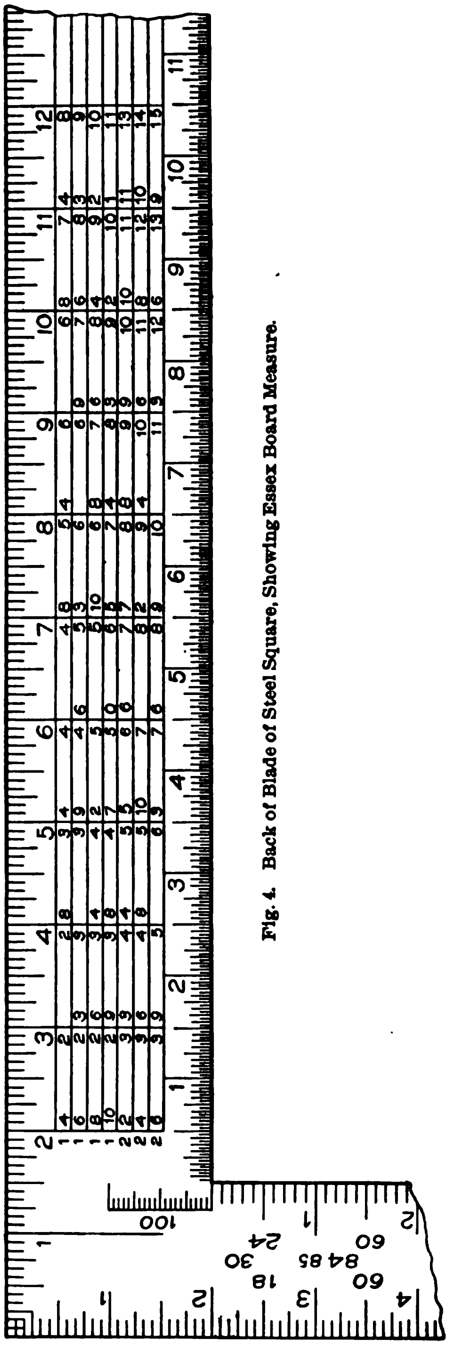


Fig. 4. Back of Blade of Steel Square, Showing Essex Board Measure.

inches wide. To find the contents, look under 12, and find 14; then follow this space along to the cross-line under 9, the width of the board; and here is found 10 feet 6 inches, denoting the contents of a board 14 feet long and 9 inches wide.

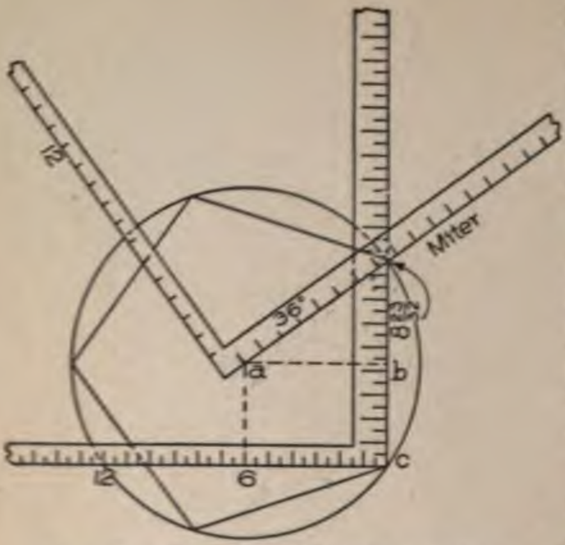


Fig. 5. Use of Steel Square to Find Miter and Side of Pentagon.

To Find the Miter and Length of Side for any Polygon, with the Steel Square. In Fig. 5 is shown a pentagon figure. The miters of the pentagon stand at 72 degrees with each other, and are found by dividing 360 by 5, the number of sides in the pentagon. But the angle when applied to the square to obtain the miter, is only one-half of 72, or 36 degrees, and intersects the blade at $8\frac{23}{32}$, as shown in Fig. 5.

By squaring up from 6 on the tongue, intersecting the degree line at *a*, the center *a* is determined either for the inscribed or the circumscribed diameter, the radii being *a b* and *a c*, respectively.

The length of the sides will be $8\frac{23}{32}$ inches to the foot.

If the length of the inscribed diameter be 8 feet, then the sides would be 8 × $8\frac{23}{32}$ inches.

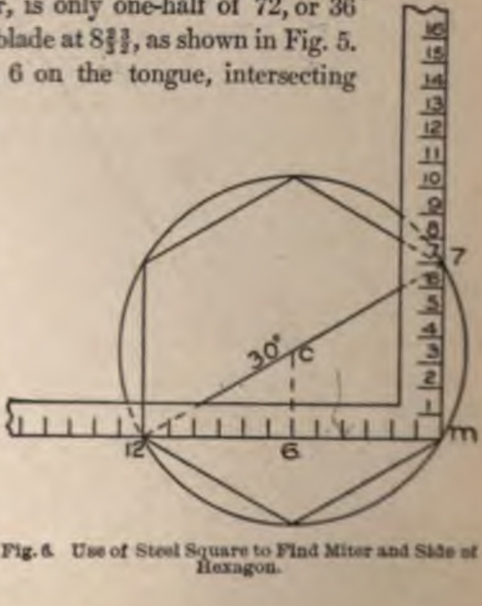


Fig. 6. Use of Steel Square to Find Miter and Side of Hexagon.

The figures to use for other polygons are as follows:

Triangle	20 25/32
Square	12
Hexagon	7
Nonagon	4 3/8
Decagon	3 7/8

In Fig. 6 the same process is used in finding the miter and side of the hexagon polygon.

To find the degree line, 360 is divided by 6, the number of sides, as follows:

360 ÷ 6 = 60; and
60 ÷ 2 = 30 degrees.

Now, from 12 on tongue, draw a line making an angle of 30 degrees with the tongue. It will cut the blade in 7 as shown; and from 7 to *m*, the heel of the square, will be the length of the side. From 6 on tongue, erect a line to cut the degree line in *c;* and with *c* as center, describe a circle having the radius of *c* 7; and around the circle, complete the hexagon by taking the length 7 *m* with the compass for each side, as shown.

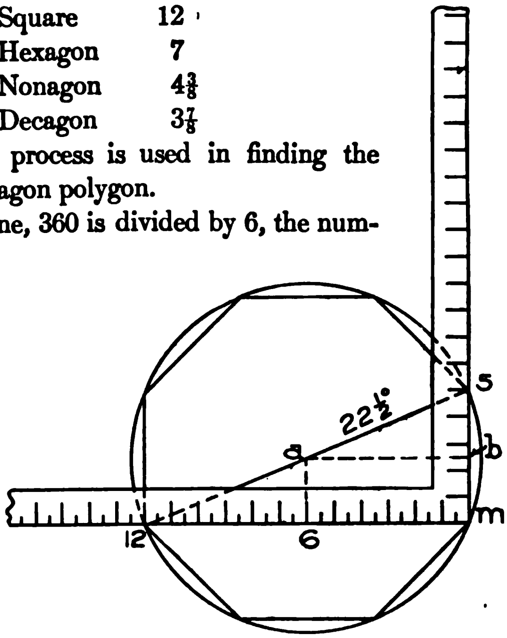


Fig. 7. Use of Steel Square to Find Miter and Side of Octagon.

In Fig. 7 the same process is shown applied to the octagon. The degree line in all the polygons is found by dividing 360 by the number of sides in the figure:

360 ÷ 8 = 45; and 45 ÷ 2 = 22½ degrees.

This gives the degree line for the octagon. Complete the process as was described for the other polygons.

By using the following figures for the various polygons, the miter lines may be found; but in these figures no account is taken of the relative size of sides to the foot as in the figures preceding:

Triangle	7 in.	and	4 in.
Pentagon	11 "	"	8 "
Hexagon	4 "	"	7 "
Heptagon	12½ "	"	6 "

Octagon	17 in.	and	7 in.
Nonagon	22½ "	"	9 "
Decagon	9½ "	"	3 "

The miter is to be drawn along the line of the first column, as shown for the triangle in Fig. 8, and for the hexagon in Fig. 9.

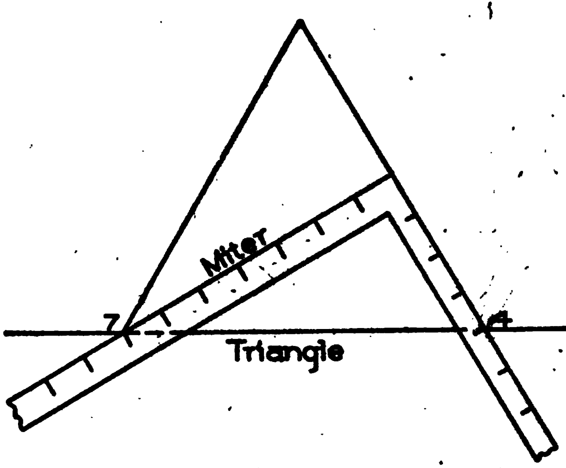


Fig. 8. Use of Square to Find Miter of Equilateral Triangle.

In Fig. 10 is shown a diagram for finding degrees on the square. For example, if a pitch of 35 degrees is required, use 8$\frac{13}{32}$ on tongue and 12 on blade; if 45 degrees, use 12 on tongue and 12 on blade; etc.

In Fig. 11 is shown the relative length of run for a rafter and a hip, the rafter being 12 inches and the hip 17 inches. The reason, as shown in this diagram, why 17 is taken for the run of the hip, instead of 12 as for the common rafter, is that the seats of the common rafter and hip do not run parallel with each other, but diverge in roofs of equal pitch at an angle of 45 degrees; therefore, 17 inches taken on the run of the hip is equal to only 12 inches when taken on that of the common rafter, as shown by the dotted line from heel to heel of the two squares in Fig. 11.

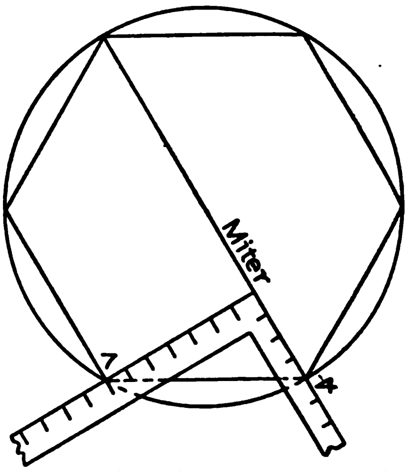


Fig. 9. Use of Square to Find Miter of Hexagon.

In Fig. 12 is shown how other figures on the square may be found for corners that deviate from the 45 degrees. It is shown that for a pentagon, which makes a 36-degree angle with the plate, the figure to be used on the square for run is 14⅞ inches; for a hexagon, which makes a 30-degree angle with the plate, the figure will be 13⅞ inches; and for an octagon, which makes an angle of 22½ degrees with the plate, the figure to use on the square for run of hip to correspond to the run of the common rafters, will be 13 inches. It will be observed that the height in each case is 9 inches.

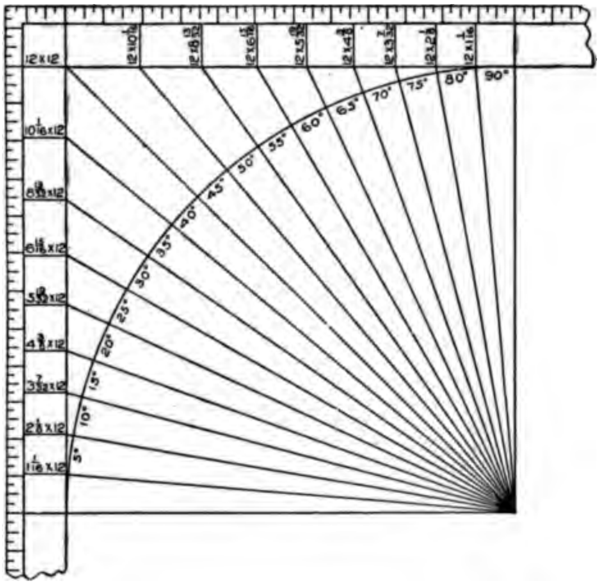


Fig. 10. Diagram for Finding Pitches of Various Degrees by Means of the Steel Square.

Fig. 13 illustrates a method of finding the relative height of a hip or valley per foot run to that of the common rafter. The square is shown placed with 12 on blade and 9 on tongue for the common rafter; and shows that for the hip the rise is only $6\frac{6}{17}$ inches.

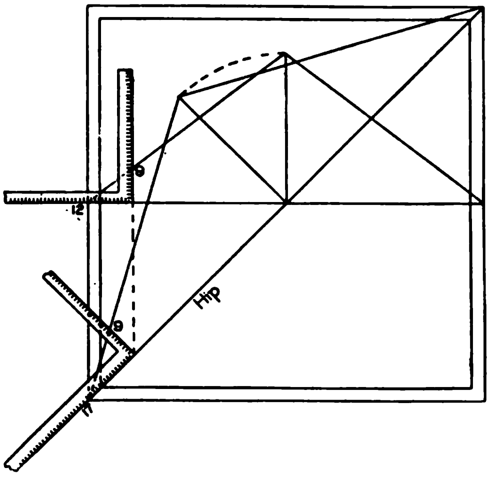


Fig. 11. Square Applied to Determine Relative Length of Run for Rafter and Hip.

The Steel Square as Applied in Roof Framing. Roof framing at present is as simple as it possibly can be, so that any attempt at a new method would be superfluous. There may, however, be a certain way of presenting the subject that will carry with it almost the weight assigned to a new theory, making what is already simple still more simple.

The steel square is a mighty factor in roof framing, and without doubt the greatest tool in practical potency that ever was invented for the carpenter. With its use the lengths and bevels of every piece of timber that goes into the construction of the most intricate design of roof, can easily be obtained, and that with but very little knowledge of lines.

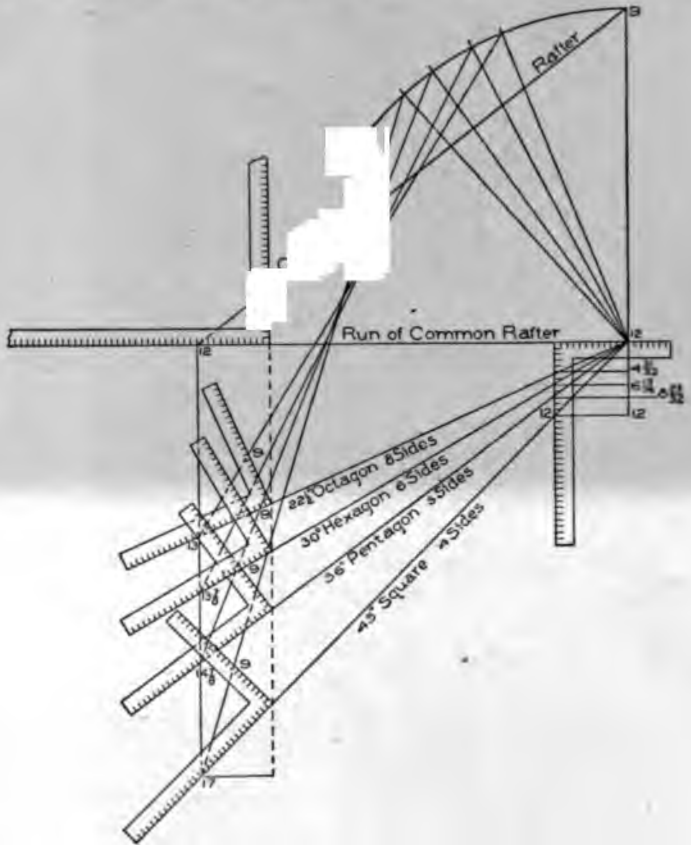
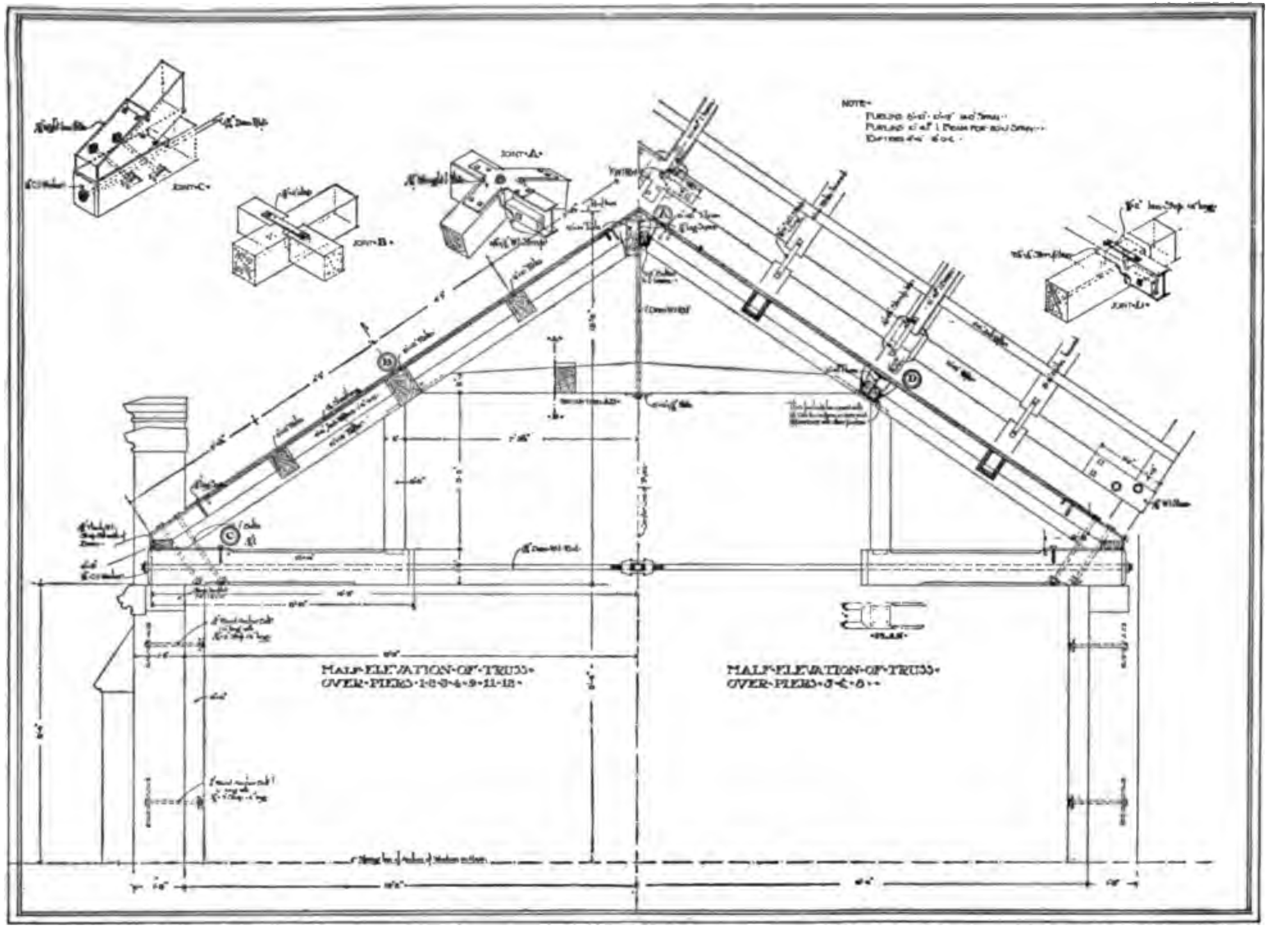
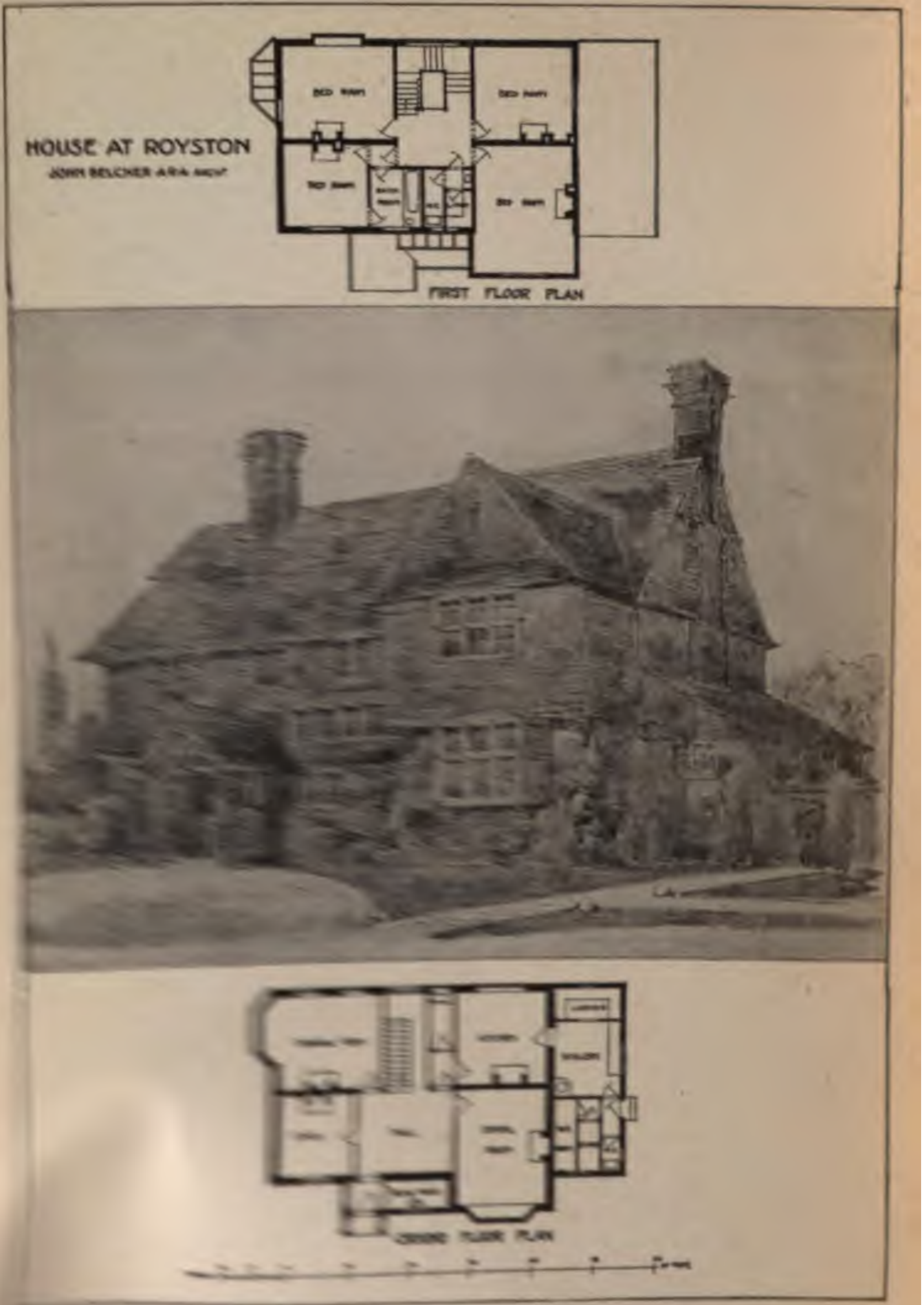


Fig. 12. Use of Square to Determine Length of Run for Rafters on Corners Other than 45°.

In roofs of equal pitch, as illustrated in Fig. 14, the steel square is all that is required if one properly understands how to handle it.



STRUCTURAL WOODEN ROOF TRUSS IN FIRST PRESBYTERIAN CHURCH, SYRACUSE, N. Y.
Tracy & Swartwout, Architects; Ballantyne & Evans, Associated.
Reproduced by courtesy of "The Architectural Review."



HOUSE AT ROYSTON, ENGLAND.

John Belcher, A. R. A., Architect.

Red Bricks with Overhanging Tiles and a Tiled Roof. The Entrance Porch is of Oak

by permission from *"Modern Cottage Architecture," John Lane Co., Publishers*

What is meant by a *pitch* of a roof, is the number of inches it rises to the foot of run.

In Fig. 15 is shown the steel square with figures representing the various pitches to the foot of run. For the ½-pitch roof, the figures as shown, from 12 on tongue to 12 on blade, are those to be used on the steel square for the common rafter; and for ⅜ pitch, the figures to be used on the square will be 12 and 9, as shown.

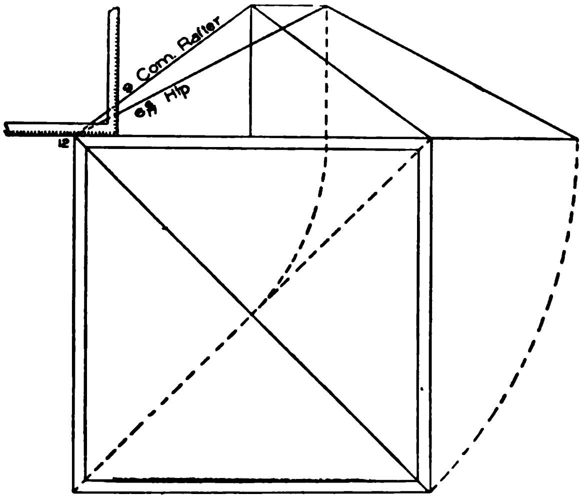


Fig. 13. Method of Finding Relative Height of Hip or Valley per Foot of Run to that of Common Rafter.

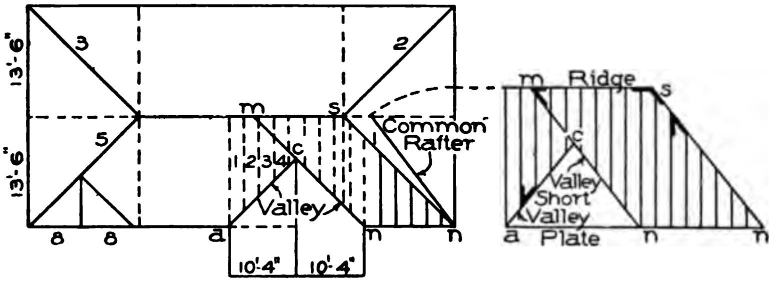


Fig. 14. Diagram to Illustrate Use of Steel Square in Laying Out Timbers of Roofs of Equal Pitch.

To understand this figure, it is necessary only to keep in mind that the pitch of a roof is reckoned from the span. Since the run in each pitch as shown is 12 inches, the span is two times 12 inches, which equals 24 inches; hence, 12 on blade to represent the foot run, and 12 on tongue to represent the rise over ½ the span, will be the figures on the square for a ½-pitch roof.

For the ⅜ pitch, the figures are shown to be 12 on tongue and 9 on blade, 9 being ⅜ of the span, 24 inches.

The same rule applies to all the pitches. The ⅙ pitch is shown to rise 4 inches to the foot of run, because 4 inches is ⅙ of the span, 24 inches, the ⅓ pitch is shown to rise 8 inches to the foot of run, because 8 inches is ⅓ of the span, 24 inches; etc.

The roof referred to in Figs. 16 and 17 is to rise 9 inches to the foot of run; it is therefore a ⅜-pitch roof. For all the common rafters, the figures to be used on the square will be 12 on blade to represent the run, and 9 on tongue to represent the rise to the foot of run; and for all the hips and valleys, 17 on blade to represent the run, and 9 on tongue to represent the rise of the roof to the foot of run.

Why 17 represents the run for all the hips and valleys, will be understood by examining Fig. 19, in which 17 is shown to be the diagonal of a foot square.

In equal-pitch roofs the corners are square, and the plan of the hip or valley will always be a diagonal of a square corner as shown at 1, 2, 3, and 5 in Fig. 14.

In Fig. 18 are shown ⅙ pitch, ⅜ pitch and ½ pitch over a square corner. The figures to be used on the square for the hip, will be 17 for run in each case. For the ⅙ pitch, the figures to be used would be 17 inches run and 4 inches rise, to correspond with the 12 inches run and 4 inches rise of the common rafter. For the ⅜ pitch, the figures to be used for hip would be 17 inches run and 9 inches rise, to corre-

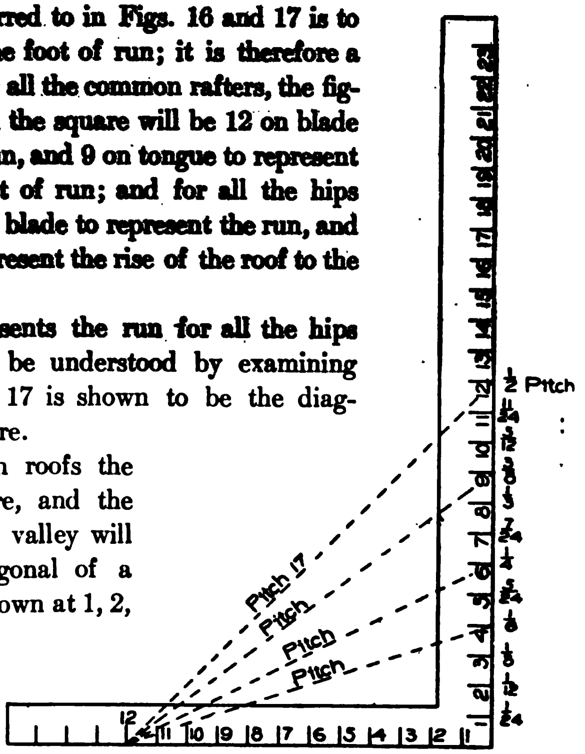


Fig. 15. Steel Square Giving Various Pitches to Foot of Run.

spond with the 12 inches run and 9 inches rise of the common rafter; and for the ½ pitch, the figures to be used on the square will be 17 inches run and 12 inches rise, to correspond with the 12 inches run and 12 inches rise of the common rafter.

It will be observed from above, that in all cases where the plan of the hip or valley is a diagonal of a square, the figures to be used on the square for run will be 17 inches; and for the rise, whatever the roof rises to the foot of run. It should also be remembered that this is the condition in all roofs of equal pitch, where the angle of the hip or valley is a 45-degree angle, or, in other words, where we have the diagonal of a square.

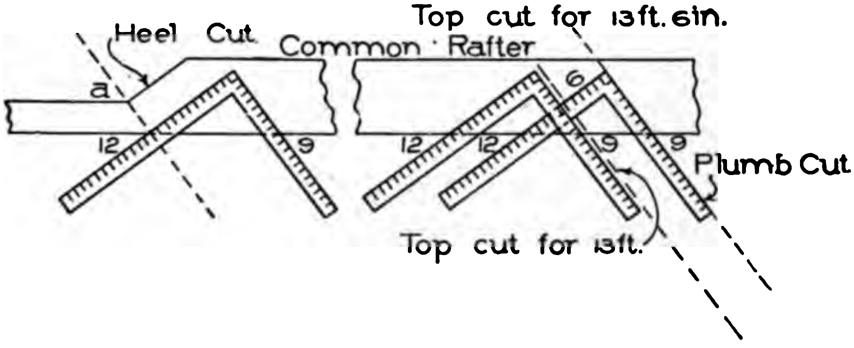


Fig. 16. Method of Laying Out Common Rafters of a ⅜-Pitch Roof.

It has been shown in Fig. 12 how other figures for other plan angles may be found; and that in each case the figures for run vary according to the plan angle of the hip or valley, while the figure for the height in each case is similar.

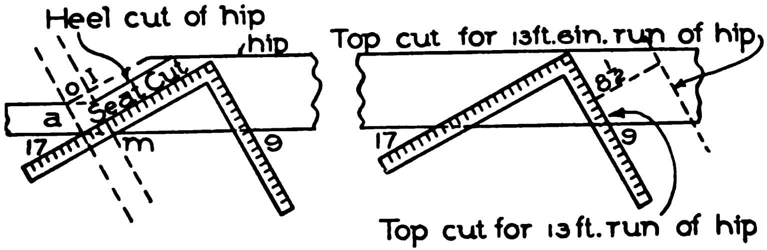

Heel cut of hip
hip
Seat Cut
a
17
m
9
Top cut for 13ft.6in. run of hip
8½
17
9
Top cut for 13ft. run of hip

Fig. 17. Method of Laying Out Hips and Valleys of a ⅜-Pitch Roof.

In Fig. 14 are shown a variety of runs for common rafters, but all have the same pitch; they rise 9 inches to the foot of run. The main roof is shown to have a span of 27 feet, which makes the run of the common rafter 13 feet 6 inches. The run of the front wing is shown to be 10 feet 4 inches; and the run of the small gable at the left corner of the front, is shown to be 8 feet.

The diversity exhibited in the runs, and especially the fractional part of a foot shown in two of them, will afford an opportunity to treat of the main difficulties in laying out roof timbers in roofs of equal pitch. Let it be determined to have a rise of 9 inches to the foot of run; and in this connection it may be well to remember that the proportional rise to the foot run for roofs of equal pitch makes not the least difference in the method of treatment.

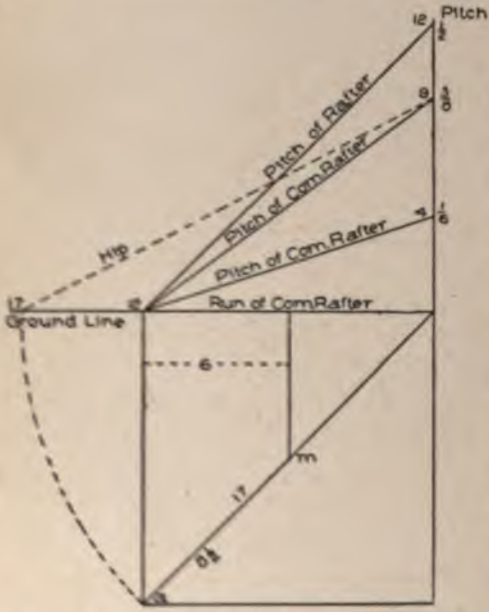


Fig. 18. Method of Laying Out Hips and Rafters for Roofs of Various Pitches over Square Corner.

To lay out the common rafters for the main roof, which has a run of 13 feet 6 inches, proceed as shown in Fig. 16.

Take 12 on the blade and 9 on the tongue, and step 13 times along the rafter timber. This will give the length of rafter for 13 feet of run. In this example, however, there is another 6 inches of run to cover. For this additional length, take 6 inches on the blade (it being ½ a foot run) for run, and take ½ of 9 on the tongue (which is 4½ inches), and step one time. This, in addition to what has already been found by stepping 13 times with 12 and 9, will give the full length of the rafter.

The square with 12 on blade and 9 on tongue will give the heel and plumb cuts.

Another method of finding the length of rafter for the 6 inches is shown in Fig. 16, where the square is shown applied to the rafter timber for the plumb cut. Square No. 1 is shown applied with 12 on blade and 9 on tongue for the length of the 13 feet. Square from this cut, measure 6 inches, the additional inches in the run; and to this point move the square, holding it on the side of the rafter timber with 12 on blade and 9 on tongue, as for a full foot run.

It will be observed that this method is easily adapted to find any fractional part of a foot in the length of rafters.

In the front gable, Fig. 14, the fractional part of a foot is 4 inches to be added to 10 feet of run; therefore, in that case, the line shown measured to 6 inches in Fig. 16 would measure only 4 inches for the front gable.

Heel Cut of Common Rafter. In Fig. 16 is also shown a method to lay out the heel cut of a common rafter. The square is shown applied with 12 on blade and 9 on tongue; and from where the 12 on the square intersects the edge of the rafter timber, a line is drawn square to the blade as shown by the dotted line from 12 to *a*. Then the thickness of the part of the rafter that is to project beyond the plate to hold the cornice, is gauged to intersect the dotted line at *a;* and from *a*, the heel cut is drawn with the square having 12 on blade and 9 on tongue, marking along the blade for the cut.

The common rafter for the front wing, which is shown to have a run of 10 feet 4 inches, is laid out precisely the same, except that for this rafter the square with 12 on blade and 9 on tongue will have to be stepped along the rafter timber only 10 times for the 10 feet of run; and for the fractional part of a foot (4 inches) which is in the run, either of the two methods already shown for the main rafter may be used.

The proportional figures to be used on the square for the 4 inches will be 4 on blade and 2¼ on tongue; and if the second method is used, make the addition to the length of rafter for 10 feet, by drawing a line 4 inches square from the tongue of square No. 1 (see Fig. 16), instead of 6 inches as there shown for the main rafter.

Hips. Three of the hips are shown in Fig. 14 to extend from the plate to the ridge-pole; they are marked in the figure as 1, 2, and 3 respectively, and are shown in plan to be diagonals of a square measuring 13 feet 6 inches by 13 feet 6 inches; they make an angle, therefore, of 45 degrees with the plate.

18 it has been shown that a hip standing at an angle of with the plate will have a run of 17 inches for every foot of the common rafter. Therefore, to lay out the hips, the figures re will be 17 for run and 9 for rise; and by stepping 13 the hip rafter timber, the length of hip for 13 feet of run The length for the additional 6 inches in the run may squaring a distance of 8½ inches, as shown in Fig. 17, from the tongue of the square, and moving square No. 1 along the edge timber, holding the blade on d tongue on 9, and marking umb cut where the dotted line wn.

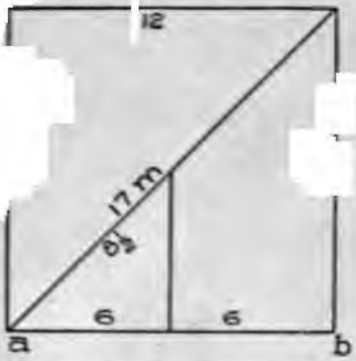


Fig. 18. Diagram Showing Relative Lengths of Run for Hips and Common Rafters in Equal-Pitch Roofs.

Fig. 18 is shown how to find the e run length of a portion of a correspond to that of a frac- part of a foot in the length e common rafter. From 12 s, measure along the run of the ommon rafter 6 inches, and drop a line to cut the diagonal line in *m*. From *m* to *a*, along the diagonal line, will be the relative run length of the part of hip to correspond with 6 inches run of the common rafter, and it measures 8½ inches.

The same results may be obtained by the following method of figuring:

As 12 : 17 : : 6
6
12)102
8 – 6 = 8½

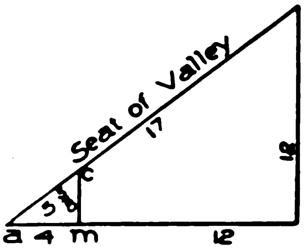


Fig. 20. Method of Determining Run of Valley for Additional Run in Common Rafter.

In Fig. 19 is shown a 12-inch square, the diagonal *m* being 17 inches. By drawing lines from the base *a b* to cut the diagonal line, the part of the hip to correspond to that of the common rafter will be indicated on the line 17. In this figure it is shown that a 6-inch run on *a b*, which represents the run of a foot of a common rafter, will have a corresponding length of 8½ inches run on the line 17, which represents the plan line of the hip or valley in all equal-pitch roofs.

In the front gable, Fig. 14, it is shown that the run of the common rafter is 10 feet 4 inches. To find the length of the common rafter, take 12 on blade and 9 on tongue, and step 10 times along the rafter timber; and for the fractional part of a foot (4 inches), proceed as was shown in Fig. 16 for the rafter of the main roof; but in this case measure out square to the tongue of square No. 1, 4 inches instead of 6 inches.

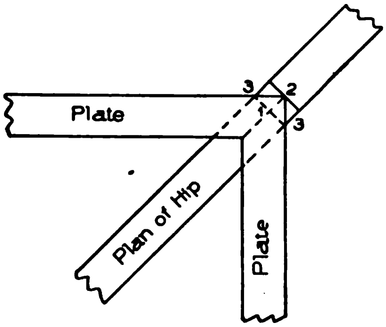


Fig. 21. Corner of Square Building, Showing Plan Lines of Plates and Hip.

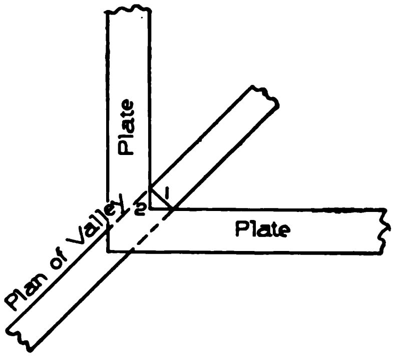


Fig. 22. Corner of Square Building, Showing Plan Lines of Plates and Valley.

The additional length for the fractional 4 inches run can also be found by taking 4 inches on blade and 3 inches on tongue of square, and stepping one time; this, in addition to the length obtained by stepping 10 times along the rafter timber with 12 on blade and 9 on tongue, will give the full length of the rafter for a run of 10 feet 4 inches.

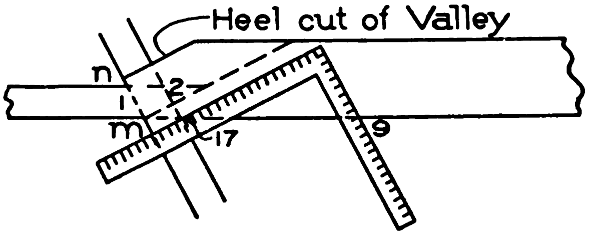


Fig. 23. Use of Square to Determine Heel Cut of Valley.

In the intersection of this roof with the main roof, there are shown to be two valleys of different lengths. The long one extends from the plate at *n* (Fig. 14) to the ridge of the main roof at *m;* it has therefore a run of 13 feet 6 inches. For the length, proceed as for the hips, by taking 17 on blade of the square and 9 on tongue, and stepping 13 times for the length of the 13 feet; and for the fractional 6 inches, proceed precisely as shown in Fig. 17 for the hip, by squaring out from the tongue of square No. 1, 8½ inches; this, in addition to the length obtained for the 13 feet, will give the full length of the long valley *n m*.

The length of the short valley *a c*, as shown, extends over the run of 10 feet 4 inches, and butts against the side of the long valley at *c*. By taking 17 on blade and 9 on tongue, and stepping along the rafter timber 10 times, the length for the 10 feet is found; and for the 4 inches, measure 5⅝ inches square from the tongue of square No. 1, in the manner shown in Fig. 17, where the 8½ inches is shown added for the 6 inches additional run of the main roof for the hips.

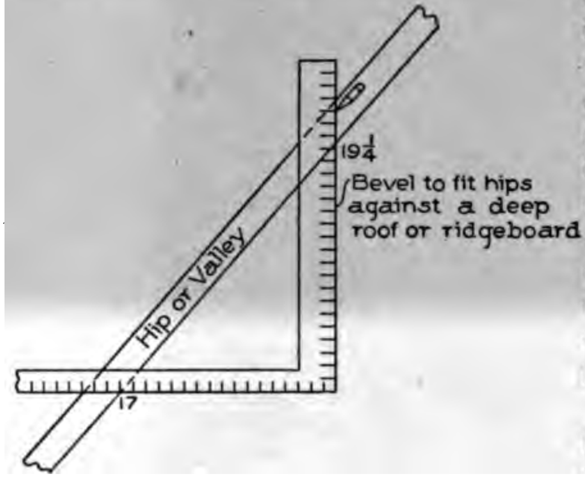


Fig. 24. Steel Square Applied to Finding Bevel for Fitting Top of Hip or Valley to Ridge.

The length 5⅝ is found as shown in Fig. 20, by measuring 4 inches from *a* to *m* along the run of common rafter for one foot. Upon *m* erect a line to cut the seat of the valley at *c;* from *c* to *a* will be the run of the valley to correspond with 4 inches run of the common rafter, and it will measure 5⅝ inches.

How to Treat the Heel Cut of Hips and Valleys. Having found the lengths of the hips and valleys to correspond to the common rafters, it will be necessary to find also the thickness of each above the plate to correspond to the thickness the common rafter will be above the plate.

In Fig. 21 is shown a corner of a square building, showing the plates and the plan lines of a hip. The length of the hip, as already found, will cover the span from the ridge to the corner 2; but the sides of the hip intersect the plates at 3 and 3 respectively; therefore the distance from 2 to 1, as shown in this diagram, is measured backwards from *a* to 1 in the manner shown in Fig. 17; then a plumb line is drawn through 1 to *m*, parallel to the plumb cut *a*-17. From *m* to *o* on this line, measure the same thickness as that of the common rafter; and through *o* draw the heel cut to *a* as shown.

In like manner the thickness of the valley above the plate is found; but as the valley as shown in the plan figure, Fig. 22, projects beyond point 2 before it intersects the outside of the plates, the distance from 2 to 1 in the case of the valley will have to be measured outwards from 2, as shown from 2 to 1 in Fig. 23; and at the point thus found the thickness of the valley is to be measured to correspond with that of the common rafter as shown at *m n*.

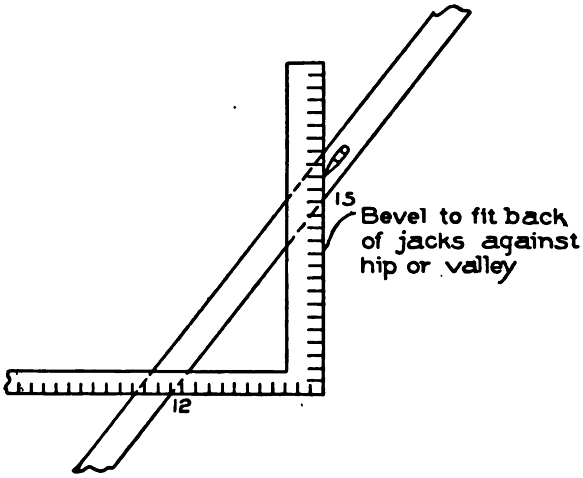


Fig. 25. Steel Square Applied to Jack Rafter to Find Bevel for Fitting against Side of Hip or Valley.

In Fig. 24 is shown the steel square applied to a hip or valley timber to cut the bevel that will fit the top end against the ridge. The figures on the square are 17 and 19¼. The 17 represents the length of the plan line of the hip or valley for a foot of run, which, as was shown in previous figures, will always be 17 inches in roofs of equal pitch, where the plan lines stand at 45 degrees to the plates and square to each other.

The 19¼ taken on the blade represents the actual length of a hip or valley that will span over a run of 17 inches. The bevel is marked along the blade.

The cut across the back of the short valley to fit it against the side of the long valley, will be a square cut owing to the two plan lines being at right angles to each other.

In Fig. 25 is shown the steel square applied to a jack rafter to cut the back bevel, to fit it against the side of a hip or valley. The figures on the square are 12 on tongue and 15 on blade, the 12 representing a foot run of a common rafter, and the 15 the length of a rafter that will span over a foot run; marking along the blade will give the bevel.

The rule in every case to find the back bevel for jacks in roofs of equal pitch, is to take 12 on the tongue to represent the foot run, and the length of the rafter for a foot of run on the blade, marking along the blade in each case for the bevel.

In a ½-pitch roof, which is the most common in all parts of the country, the length of rafter for a foot of run will be 17 inches; hence it will be well to remember that 12 on tongue and 17 on blade, marking along the blade, will give the bevel to fit a jack against a hip or a valley in a ½-pitch roof.

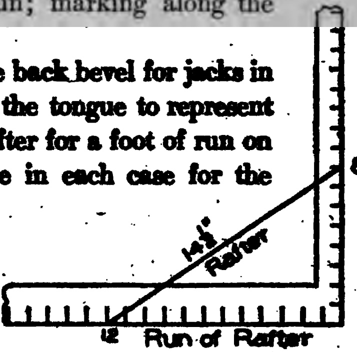


Fig. 26. Finding Length to Shorten Rafters for Jacks per Foot of Run.

In a roof having a rise of 9 inches to the foot of run, such as the one under consideration, the length of rafter for one foot of run will be 15 inches. The square as shown in Fig. 25, with 12 on tongue and 15 on blade, will give the bevel by marking along the blade.

To find the length of a rafter for a foot of run for any other pitch, place the two-foot rule diagonally from 12 on the blade of the square to the figure on tongue representing the rise of the roof to the foot of run; the rule will give the length of the rafter that will span over one foot of run.

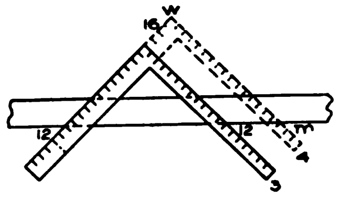


Fig. 27. Finding Length of Jack Rafter in ½-Pitch Roof.

The length of rafter for a foot of run will also determine the difference in lengths of jacks. For example, if a roof rises 12 inches to one foot of run, the rafter over this span has been found to be 17 inches; this, therefore, is the number of inches each jack is shortened in one foot of run. If the rise of the roof is 8 inches to the foot of run, the length of the rafter is found for one foot of run, by placing the rule diagonally from 12 on tongue to 8 on blade, which gives 14½ inches, as shown in Fig. 26. This, therefore, will be the number of inches the jacks are to be shortened in a roof rising 8 inches to the foot of run. If the jacks are placed 24 inches from center to center, then multiply 14½ by 2 = 29 inches.

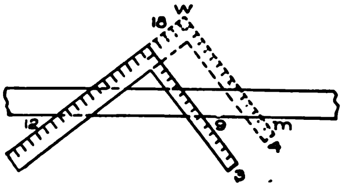


Fig. 28. Finding Length of Jack Rafter in ⅜-Pitch Roof.

In Fig. 27 is shown how to find the length with the steel square. The square is placed on the jack timber rafter with the figures that have been used to cut the common rafter. In Fig. 27, 12 on blade and 12 on tongue were the figures used to cut the common rafter, the roof being ½ pitch, rising 12 inches to the foot of run. In the diagram it is shown how to find the length of a jack rafter if placed 16 inches from center to center. The method is to move the square as shown along the line of the blade until the blade measures 16 inches; the tongue then would be as shown from *w* to *m*, and the length of the jack would be from 12 on blade to *m* on tongue, on the edge of the jack rafter timber as shown.

This latter method becomes convenient when the space between jacks is less than 18 inches; but if used when the space is more than 18 inches it will become necessary to use two squares; otherwise the tongue as shown at *m* would not reach the edge of the timber.

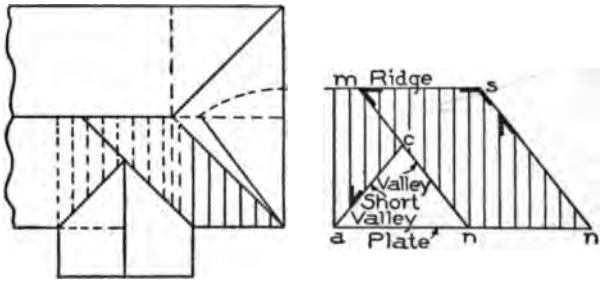


Fig. 29. Method of Determining Length of Jacks Between Hips and Valleys; also Bevels for Jacks, Hips, and Valleys.

In Fig. 28 the same method is shown for finding the length of a jack rafter for a roof rising 9 inches to the foot of run, with the jacks placed 18 inches center to center. The square in this diagram is shown placed on the jack rafter timber with 12 on blade and 9 on gue; then it is moved forward along the line of the blade to *w*. blade, when in this latter position, will measure 18 inches. The tongue will meet the edge of the timber at *m*, and the distance from *m* on tongue to 12 on blade will indicate the length of a jack, or, in ther words, will show the length each jack is shortened when placed

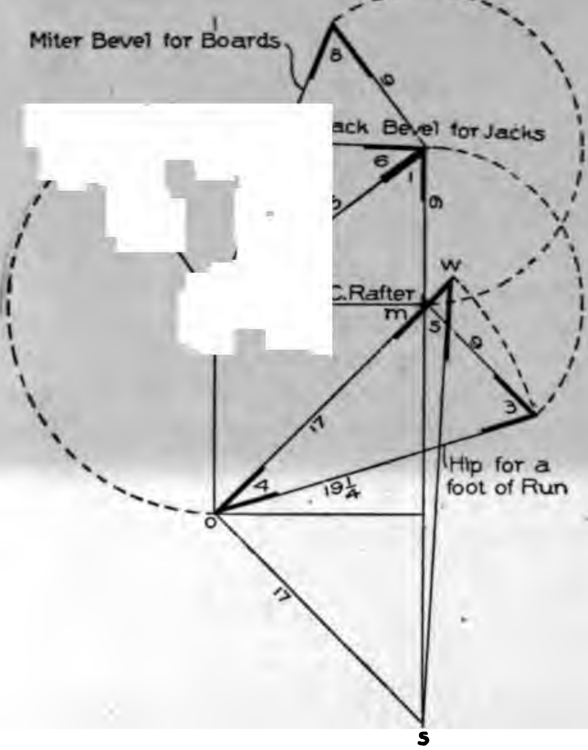


Fig. 30. Method of Finding Bevels for All Timbers in Roofs of Equal Pitch.

18 inches between centers in a roof having a pitch of 9 inches to the foot of run.

When jacks are placed between hips and valleys as shown at 1, 2, 3, 4, etc., in Fig. 14, a better method of treatment is shown in Fig. 29, where the slope of the roof is projected into the horizontal plane. The distance from the plate in this figure to the ridge *m*, equals the length of the common rafter for the main roof. On the plate *a n n* is made equal to *a n n* in Fig. 14. By drawing a figure like this to a scale of one inch to one foot, the length of all the jacks can be measured and also the lengths of the hip and the two valleys. It also gives the bevels for the jacks, as well as the bevel to fit the hip and valley against the ridge; but this last bevel must be applied to the hip and valley when backed.

It has been shown before, that the figures to be used on the square for this bevel when the timber is left square on back as is the custom in construction, are the length of a foot run of a hip or valley, which is 17, on tongue, and the length of a hip or valley that will span over 17 inches run, on blade—the blade giving the bevel.

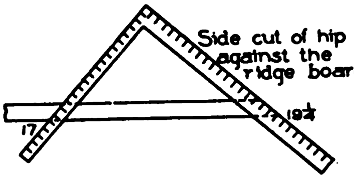


Fig. 31. Method of Finding Bevel 5, Fig. 30, for Fitting Hip or Valley Against Ridge when not Backed.

Fig. 30 contains all the bevels or cuts that have been treated upon so far, and, if correctly understood, will enable any one to frame any roof of equal pitch. In this figure it is shown that 12 inches run and 9 inches rise will give bevels 1 and 2, which are the plumb and heel cuts of rafters of a roof rising 9 inches to the foot of run. By taking these figures, therefore, on the square, 9 inches on the tongue and 12 inches on the blade, marking along the tongue will give the plumb cut, and marking along the blade will give the heel cut.

Bevels 3 and 4 are the plumb and heel cuts for the hip, and are shown to have the length of the seat of hip for one foot run, which is 17 inches. By taking 17 inches, therefore, on the blade, and 9 inches on the tongue, marking along the tongue for the plumb cut, and along the blade for the heel cut, the plumb and heel cuts are found. Bevel 5, which is to fit the hip or valley against the ridge when not backed, is shown from *o w*, the length of the hip for one foot of run, which is 19¼ inches, and from *o s*, which always in roofs of equal pitch will be 17 inches and equal in length to the seat of a hip or valley for one foot of run.

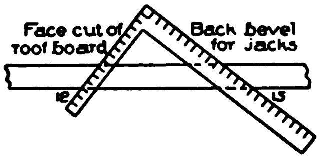


Fig. 32. Method of Finding Back Bevel 6, Fig. 30, for Jack Rafters, and Bevel 7, for Roof-Board.

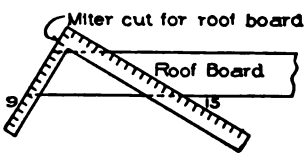


Fig. 33. Determining Miter Cut for Roof-Board.

These figures, therefore, taken on the square, 19¼ on the blade, and 17 on the tongue, will give the bevel by marking along the blade as shown in Fig. 31, where the square is shown applied to the hip timber with 19¼ on blade and 17 on tongue, the blade showing the cut.

Bevels 6 and 7 in Fig. 30 are shown formed of the length of the rafter for one foot of run, which is 15 inches, and the run of the rafter, which is 12 inches. These figures are applied on the square, as shown in Fig. 32, to a jack rafter timber; taking 15 on the blade and 12 on the tongue, marking along the blade will give the back bevel for the jack rafters, and marking along the tongue will give the face cut of roof-boards to fit along the hip or valley.

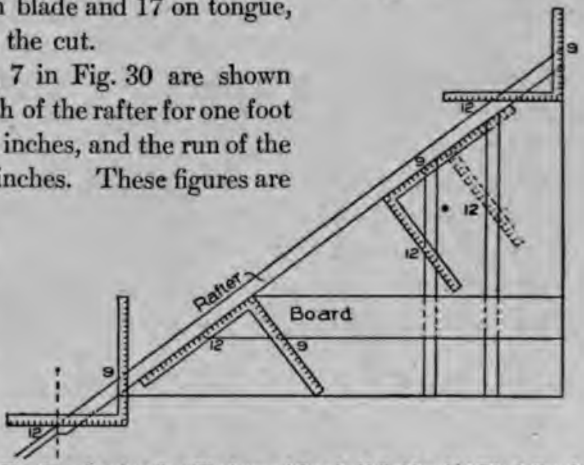


Fig. 34. Laying Out Timbers of One-half Gable of ⅜-Pitch Roof.

It is shown in Fig. 30, also, that by taking the length of rafter 15 inches on blade, and rise of roof 9 inches on tongue, bevel 8 will give the miter cut for the roof-boards.

In Fig. 33 the square is shown applied to a roof-board with 15 on blade, which is the length of the rafter to one foot of run, and with 9 on tongue, which is the rise of the roof to the foot run; marking along the tongue will give the miter for the boards.

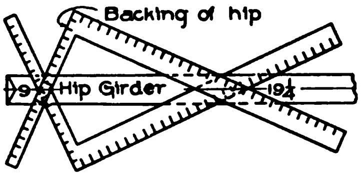


Fig. 35. Finding Backing of Hip in Gable Roof.

Other uses may be made of these figures, as shown in Fig. 34, which is one-half of a gable of a roof rising 9 inches to the foot run. The squares at the bottom and the top will give the plumb and heel cuts of the common rafter. The same figures on the square applied to the studding, marking along the tongue for the cut, will give the bevel to fit the studding against the rafter; and by marking along the blade we obtain the cut for the boards that run across the gable. By taking 19¼ on blade, which is the length of the hip for one foot of run, and taking on the tongue the rise of the roof to the foot of run, which is 9 inches, and applying these as shown in Fig. 35, we obtain the backing of the hip by marking along the tongue of the two squares, as shown.

It will be observed from what has been said, that in roofs of equal pitch the figure 12 on the blade, and whatever number of inches the roof rises to the foot run on the tongue, will give the plumb and heel cuts for the common rafter; and that by taking 17 on the blade instead of 12, and taking on the tongue the figure representing the rise of the roof to the foot run, the plumb and heel cuts are found for the hips and valleys.

By taking the length of the common rafter for one foot of run on blade, and the run 12 on tongue, marking along the blade will give the back bevel for the jack to fit the hip or valley, and marking along the tongue will give the bevel to cut the roof-boards to fit the line of hip or valley upon the roof.

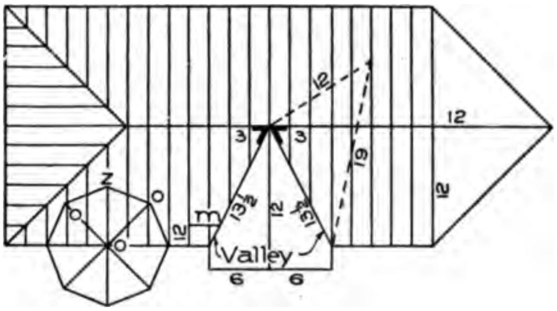


Fig. 36. Laying Out Timbers of Roof with Two Unequal Pitches.

With this knowledge of what figures to use, and why they are used, it will be an easy matter for anyone to lay out all rafters for equal-pitch roofs.

In Fig. 36 is shown a plan of a roof with two unequal pitches. The main roof is shown to have a rise of 12 inches to the foot run. The front wing is shown to have a run of 6 feet and to rise 12 feet; it has thus a pitch of 24 inches to the foot run. Therefore 12 on blade of the square and 12 on tongue will give the plumb and heel cuts for the main roof, and by stepping 12 times along the rafter timber the length of the rafter is found. The figures on the square to find the heel and plumb cuts for the rafter in the front wing, will be 12 run and 24 rise, and by stepping 6 times (the number of feet in the run of the rafter), the length will be found over the run of 6 feet, and it will measure 13 feet 6 inches.

If, in place of stepping along the timber, the diagonal of 12 and 24 is multiplied by 6, the number of feet in the run, the length may be found even to a greater exactitude.

Many carpenters use this method of framing; and to those who have confidence in their ability to figure correctly, it is a saving of time, and, as before said, will result in a more accurate measurement; but the better and more scientific method of framing is to work to a scale of one inch, as has already been explained.

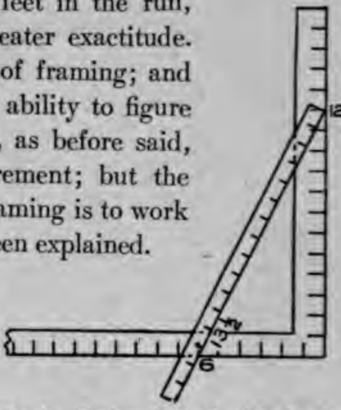


Fig. 37. Finding Length of Rafter for Front Wing in Roof Shown in Fig. 36.

According to that method, the diagonal of a foot of run, and the number of inches to the foot run the roof is rising, measured to a scale, will give the exact length. For example, the main roof in Fig. 36 is rising 12 inches to a foot of run. The diagonal of 12 and 12 is 17 inches, which, considered as a scale of one inch to a foot, will give 17 feet, and this will be the exact length of the rafter for a roof rising 12 inches to the foot run and having a run of 12 feet.

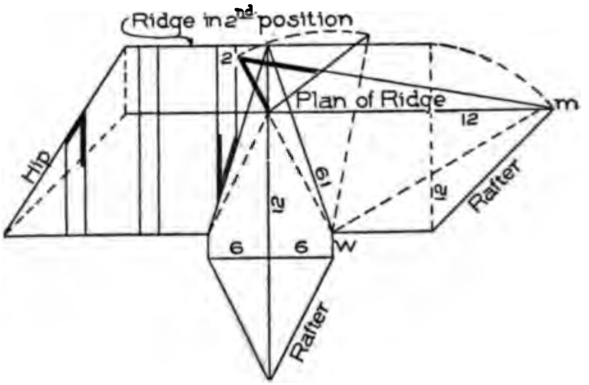


Fig. 38. Laying Out Timbers of Roof Shown in Fig. 36, by Projecting Slope of Roof into Horizontal Plane.

The length of the rafter for the front wing, which has a run of 6 feet and a rise of 12 feet, may be obtained by placing the rule as shown in Fig. 37 from 6 on blade to 12 on tongue, which will give a length of 13½ inches. If the scale be considered as one inch to a foot, this will equal 13 feet 6 inches, which will be the exact length of a common rafter rising 24 inches to the foot run and having a run of 6 feet.

It will be observed that the plan lines of the valleys in this figure in respect to one another deviate from forming a right angle. In equal-pitch roofs the plan lines are always at right angles to each other, and therefore the diagonal of 12 and 12, which is 17 inches, will be the relative foot run of valleys and hips in equal-pitch roofs.

In Fig. 36 is shown how to find the figures to use on the square for valleys and hips when deviating from the right angle. A line is drawn at a distance of 12 inches from the plate and parallel to it, cutting the valley in *m* as shown. The part of the valley from *m* to the plate will measure 13½ inches, which is the figure that is to be used on the square to obtain the length and cuts of the valleys.

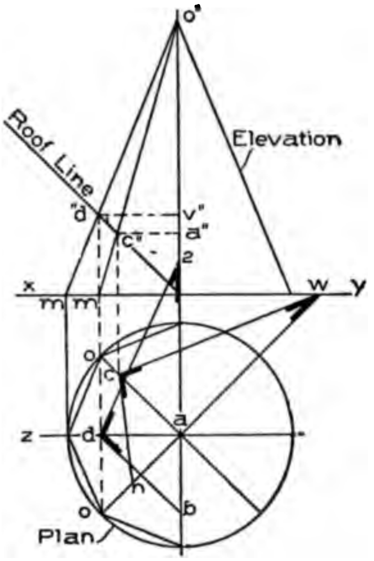


Fig. 39. Method of Finding Length and Cuts of Octagon Hips Intersecting a Roof.

It will be observed that this equals the length of the common rafter as found by the square and rule in Fig. 37. In that figure is shown 12 on tongue and 6 on blade. The 12 here represents the rise, and the 6 the run of the front roof. If the 12 be taken to represent the run of the main roof, and the 6 to represent the run of the front roof, then, the diagonal 13½ will indicate the length of the seat of the valley for 12 feet of run, and therefore for one foot it will be 13½ inches. Now, by taking 13½ on the blade for run, and 12 inches on the tongue for rise, and stepping along the valley rafter timber 12 times, the length of the valley will be found. The blade will give the heel cut, and the tongue the plumb cut.

In Fig. 38 is shown the slope of the roof projected into the horizontal plane. By drawing a figure based on a scale of one inch to one foot, all the timbers on the slope of the roof can be measured. Bevel 2, shown in this figure, is to fit the valleys against the ridge. By drawing a line from *w* square to the seat of the valley to *m*, making *w* 2 equal in length to the length of the valley, as shown, and by connecting 2 and *m*, the bevel at 2 is found, which will fit the valleys against the ridge, as shown at 3 and 3 in Fig. 36.

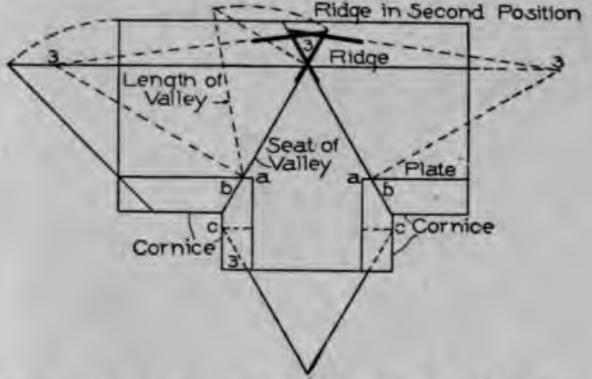


Fig. 40. Showing How Cornice Affects Valleys and Plates in Roof with Unequal Pitches.

In Fig. 39, is shown how to find the length and cuts of octagon hips intersecting a roof. In Fig. 36, half the plan of the octagon is shown to be inside of the plate, and the hips *o*, *z*, *o* intersect the slope of the roof. In Fig. 39, the lines below *x y* are the plan lines; and those above, the elevation. From *z*, *o*, *o*, in the plan, draw lines to *x y*, as shown from *o* to *m* and from *z* to *m*; from *m* and *m*, draw the elevation lines to the apex *o''*, intersecting the line of the roof in *d''* and *c''*. From *d''* and *c''*, draw the lines *d'' v''* and *c'' a''* parallel to *x y*; from *c''*, drop a line to intersect the plan line *a o* in *c*. Make *a w* equal in length to *a'' o''* of the elevation, and connect *w c*; measure from *w* to *n* the full height of the octagon as shown from *x y* to the apex *o''*; and connect *c n*. The length from *w* to *c* is that of

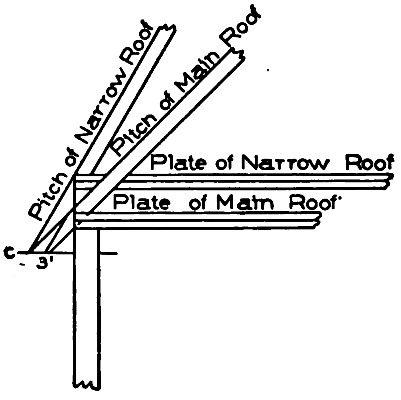


Fig. 41. Showing Relative Position of Plates in Roof with Two Unequal Pitches.

the two hips shown at *o o* in Fig. 36, both being equal hips intersecting the roof at an equal distance from the plate. The bevel at *w* is the top bevel, and the bevel at *c* will fit the roof.

Again, drop a line from d'' to intersect the plan line *a z* in *d*. Make *a* 2 equal to $v''\ o''$ in the elevation, and connect 2 *d*. Measure from 2 to *b* the full height of the tower as shown from *x y* to the apex o'' in the elevation, and connect *d b*. The length 2 *d* represents the length of the hip *z* shown in Fig. 36; the bevel at 2 is that of the top; and the bevel at *d*, the one that will fit the foot of the hip to the intersecting roof.

When a cornice of any considerable width runs around a roof of this kind, it affects the plates and the angle of the valleys as shown in Fig. 40. In this figure are shown the same valleys as in Fig. 36; but, owing to the width of the cornice, the foot of each has been moved the distance *a b* along the plate of the main roof. Why this is done is shown in the drawing to be caused by the necessity for the valleys to intersect the corners *c c* of the cornice.

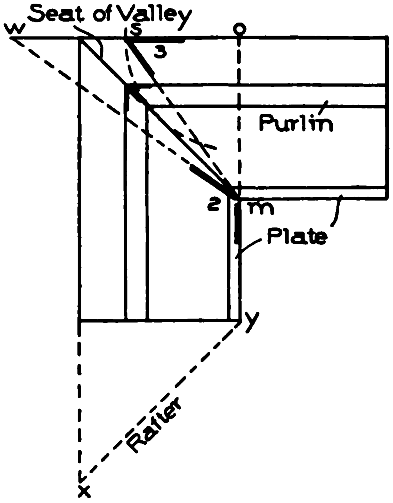


Fig. 42. Method of Finding Bevels for Purlins in Equal-Pitch Roofs.

The plates are also affected as shown in Fig. 41, where the plate of the narrow roof is shown to be much higher than the plate of the main roof.

The bevels shown at 3, Fig. 40, are to fit the valleys against the ridge.

In Fig. 42 is shown a very simple method of finding the bevels for purlins in equal-pitch roofs. Draw the plan of the corner as shown, and a line from *m* to *o*; measure from *o* the length *x y*, representing the common rafter, to *w*; from *w* draw a line to *m*; the bevel shown at 2 will fit the top face of the purlin. Again, from *o*, describe an arc to cut the seat of the valley, and continue same around to *S*; connect *S m*; the bevel at 3 will be the side bevel.

REVIEW QUESTIONS.

PRACTICAL TEST QUESTIONS.

In the foregoing sections of this Cyclopedia numerous illustrative examples are worked out in detail in order to show the application of the various methods and principles. Accompanying these are examples for practice which will aid the reader in fixing the principles in mind.

In the following pages are given a large number of test questions and problems which afford a valuable means of testing the reader's knowledge of the subjects treated. They will be found excellent practice for those preparing for College, Civil Service, or Engineer's License. In some cases numerical answers are given as a further aid in this work.

REVIEW QUESTIONS

ON THE SUBJECT OF

CARPENTRY

PART I

1. Classify trees as to the manner of growth and explain how the structure affects their value as building material.

2. Give the characteristics of the four parts of the section of a conifer, shown in Fig. 1.

3. What effect do the medullary rays have on the lumber of such trees as the maple and oak?

4. What are the common defects of timber?

5. How can warping be prevented?

6. Explain the term "quarter sawed."

7. Mention the best framing lumber. What qualities recommend the kind mentioned?

8. White pine, red cypress, and poplar are usually considered the best lumbers to use in exposed positions. Why?

9. What qualities make yellow or hard pine so popular?

10. Classify lumber as hard wood and soft wood. State the more common uses of each kind.

11. Name the common tools used in woodworking.

12. How does the action of the rip saw differ from that of the cross-cut saw?

13. Explain the uses of each kind of plane.

14. What operations constitute "laying out"?

15. How is the 3—4—5 rule used?

16. Give directions for constructing and setting batter-boards.

17. From the information given in the text, discuss the availability of the different kinds of wood to be used for shingles.

18. What is *bird's-eye maple?*

19. Name the three parts of a steel square.

20. What precaution should be taken in regard to ground water?

21. Distinguish between the two growths of timber known as endogenous and exogenous.

22. Explain how the exogenous trees increase in height and circumference.

23. Discuss the comparative value of the heartwood and sapwood.

24. Draw a sketch showing the general structure of some common kind of wood.

25. What is the u[illegible]ry rot and how may this be overcome?

REVIEW QUESTIONS

ON THE SUBJECT OF

CARPENTRY

PART II

1. Name the principal parts of a frame.
2. Illustrate and describe a splice joint; a square butt joint; an oblique butt joint.
3. Which of the three is the strongest?
4. Illustrate three different methods of joining joists to girders.
5. Illustrate and describe two joints particularly adapted for tension.
6. Upon what does the strength of the joint shown in Fig. 61 depend?
7. What is a spline; and how is it used?
8. Under what circumstances would the dovetail key illustrated in Fig. 84 be used? When would you use the method illustrated in Fig. 85?
9. Distinguish between a balloon and a braced frame.
10. Give the special advantages of the balloon frame and state why, in your opinion, it has become so popular.
11. What method would you use to make a sill set firmly on a foundation?
12. What method would you use to prevent the moisture in foundation from causing dry rot?
13. Illustrate as many different kinds of corner posts as you are familiar with.
14. What advantages has the ledger board over a girt? Which is preferable in balloon framing?

15. Describe and illustrate a good method of forming the corners of inside rooms so that there will be a nailing for the lath.

16. What precaution should be taken in preparing for plaster around the chimney? Illustrate the method which you think best.

17. Upon what principle does the effect of diagonal bridging depend?

18. Discuss the relative value of the use of joist hangers and the use of gains in supporting girders and joists. Illustrate the method which you think best.

19. Describe a good method of construction for a floor opening in front of a fireplace.

20. Why should the top of each joist be cut back where it enters a masonry wall?

21. Why are joists crowned?

22. Does the straightness of the joist have anything to do with the manner in which it should be crowned?

23. What method would you use in supporting corners where it is impossible to use a post or wall under them? Illustrate.

24. Where is the shrinkage of the lumber used in a building liable to cause trouble? How can this be avoided?

25. What special construction is desirable in the case of a partition where sliding doors are used?

REVIEW QUESTIONS

ON THE SUBJECT OF

CARPENTRY

PART III

1. Illustrate the different styles of roofs. Name each style.

2. Which style of roof is the most common for cottages?

3. What are the component parts of a roof?

4. Discuss the ordinary size of rafters. What should be the limit of length for each size?

5. Name the different kinds of rafters and draw a figure of each kind.

6. What determines the pitch of the roof; and what does one-quarter pitch mean?

7. Draw a plan of a six-room cottage with a single L and show how you would put the roof on the building.

8. Illustrate how you would obtain the length of the valley rafters in this case.

9. Draw a sketch of each of the different kinds of rafters you would use and illustrate roughly how you would lay the square on the rafters to obtain the bevels.

10. What is a double gable roof?

11. How are the proportions for a gambrel roof obtained?

12. Sketch the roof framing for a dormer window.

13. Why is it rarely necessary to back the rafters used in residences and cottages?

14. Draw an illustration of a trussed partition, stating which timbers are used in tension and which are used in compression.

15. What is a bowled floor; and where are these floors usually used?

16. How far may a balcony safely extend without bracing?

17. Illustrate a good method of framing the overhanging portion of a gallery. Give the sizes of timber you would use.

18. Define a *king-post truss.*

19. Illustrate and show which members are in tension.

20. Illustrate the queen-post truss and show the tension members.

21. Name the different kinds of trusses usually used.

22. In building a cupola or a tower, what special stresses must be taken into consideration?

23. Draw the principal members of a dome construction.

24. What members are in tension?

25. Illustrate the best method of cradling for a groined ceiling.

REVIEW QUESTIONS

ON THE SUBJECT OF

CARPENTRY

PART IV

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1. Mention the various kinds of lumber used in your neighborhood for interior finishing. For exterior finishing.

2. What is the advantage of using sheathing and building paper?

3. Illustrate the method which you consider best for the construction of a water table for a $3,000 residence.

4. Illustrate and discuss the relative advantages of wood and metal gutters.

5. Illustrate a section through a boxed cornice.

6. What is the special advantage of the concealed gutter? Where is this gutter usually used?

7. Draw a sketch showing the framing for a skylight.

8. Make a list of the different parts of a window frame.

9. Draw a cross section of the one side of the window frame, putting on dimensions which are common for frame buildings in your vicinity.

10. Name and distinguish between the different kinds of windows.

11. What is a transom? A transom window?

12. Illustrate the horizontal section through the side jamb of an interior door frame; of an exterior door frame. Name the parts.

13. Name the parts of a three-piece base. Give the dimensions usually used.

14. Sketch a common form of wainscoting.

15. Draw a careful sketch of a picture molding; a plate rail; a window sill; a mullion; a muntin.

16. Compare the relative values of shingles and clapboards as wall covering.

17. What is siding? When and how is it used?

18. What is the purpose of a belt course? Illustrate a method of construction.

19. Sketch the details used with a false rafter and show how the gutter is constructed.

20. Illustrate two methods of finishing the ridge.

21. Name the parts used in the cornice of the gable and give approximate sizes for these parts.

22. What is a verge board?

23. Illustrate outside architrave. When is this construction used?

24. Show the construction used where siding or shingles are covered by the frieze at a gable end and on a side wall.

25. What means are employed to catch the water which may blow between the joints in a casement window?

REVIEW QUESTIONS

ON THE SUBJECT OF

STAIR-BUILDING

1. Define *staircase* and *stairway.*

2. What is meant by the *rise* and *run* of a stairway? How measured?

3. Define *tread* and *riser.*

4. How do treads and risers compare as to number? Why?

5. What is a *string* or *string-board*? Describe the various kinds of strings.

6. How are treads and risers fitted together and fastened in housed strings?

7. Describe the construction and use of a *pitch-board.*

8. How are the relative dimensions of treads and risers determined?

9. Are all the risers in a flight of stairs cut of uniform height?

10. Describe the use of *flyers, winders,* and *dancing steps.*

11. How are balusters fastened on strings?

12. How are strings fastened to newel-posts?

13. Describe methods of constructing *bullnose steps* and risers for same.

14. What is the difference between a *quarter-space landing* and a *half-space landing*?

15. Define the terms: *well-hole*; *drum*; *cylinder*; *kerfing*; *geometrical stairway*; *carriage timber*; *wreath*; *tangent*; *crown tangent*; *springing of a well-hole*; *ground-line*; *swan-neck*; *face-mould*; *nosing*; *return nosing*; *spandrel*; *cove-moulding.*

16. Describe the use of the *face-mould.*

17. When the face-mould is applied, and material for the wreath cut from the plank, how is the wreath-piece given its final shape?

18. What is the use of *tangents* in handrailing? What do the *bevels* represent?

19. What is an *oblique plane*?

20. Are all wreaths assumed to be resting on an oblique plane?

21. In referring to an oblique plane, what do you understand by the expressions *inclined in one direction only* and *inclined in two directions*?

22. What is meant when two wreath tangents are said to be *equally inclined*? What, when *unequally inclined*?

23. When an oblique plane is inclined in one direction only, how many bevels will be needed to twist the wreath?

24. When the plane inclines in two directions, how many bevels are required?

25. When the inclination is equal in two directions, how many bevels are needed?

26. When the plane is unequally inclined in two directions, how many bevels are needed?

27. How can a stairway be reinforced?

28. How should a scroll bracket be terminated against the riser?

29. When a plane is equally inclined in two directions, how are the bevel or bevels to be applied to twist the wreath resting upon it in its ascent around the well-hole?

30. What is the difference between the *plan tangents, pitch-line of tangents*, and *tangents of the face-mould*?

31. Why is it necessary to determine with exactness the angle between the tangents on the face-mould?

32. What is the width of the face-mould to be, when laid out on the minor axis?

33. How is the width of the mould at the ends determined?

34. How do you find the *minor axis* and *major axis* of the mould curves?

35. Show how to find the thickness of the plank that will be required for the wreath.

36. When the plan tangents are at a right angle to each other, and the pitch is equal, how are the bevels to be applied, (1) in relation to each other; (2) in relation to the sides of the wreath?

REVIEW QUESTIONS

ON THE SUBJECT OF

THE STEEL SQUARE

1. On what part of the square will you find the *octagon scale?* Describe its use.

2. On what part of the square will you find the *brace rule?* Describe its use.

3. On what part of the square would you look for the *board measure?* Describe its use.

4. What is meant by the *pitch* of a roof?

5. What is meant by a *bevel* in roof framing?

6. Draw a diagram of a roof, indicating thereon the *ridge, common rafters, jack rafters, hips, valleys, plate.*

7. How would you lay out a pentagon by means of the square? A hexagon? Illustrate with diagrams.

8. How, with a square, would you find the miter of an equilateral triangle? Of a hexagon? Illustrate with diagrams.

9. What are meant by *plumb cut* and *heel cut?* Draw a diagram to illustrate.

10. Show how to lay out the heel cut of a common rafter.

11. Draw diagrams illustrating use of the square in finding the relative length of run for rafters and hips. Explain.

12. Show how to apply the square to a hip or valley timber to cut the bevel that will fit the top end against the ridge.

13. Describe the application of the square in finding the relative height of a hip or valley per foot of run, to that of the common rafter. Draw a diagram.

14. Describe a method of finding the bevels for purlins in equal-pitch roofs.

15. Describe, with diagram, the use of the square in cutting the back bevel to fit a jack rafter against the side of a hip or valley.

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